SCIENCE EDUCATION

MYRTLE ELIZABETH JOHNSON

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MYRTLE ELIZABETH JOHNSON

A NOTED classroom teacher of biology is recipient of the Fifteenth Science Education Recognition Award. Doctor Myrtle Elizabeth Johnson was born in East Troy, Walworth County, Wisconsin, June 4, 1881, the daughter of Dr. Theodore F. Johnson and Marian Gray Johnson. She has a sister, Mrs. George R. Livingston (a former teacher) living in San Diego California, and a brother, Halbert Theodore Johnson, a civil engineer living at Paso Robles, California.

Commenting on her ancestors, Dr. Johnson says:

My father's parents, Ephriam Johnson and Maria Park Johnson were descended from farmers, early settlers in Grafton and Weston, Vermont. Father moved with the family to Wisconsin when he was ten years old.

Maternal grandparents came from England in 1846 as members of a Temperance Emigration Society which had agreed to provide its members with a house and farm when they were ready to go to America. The farm included 40 acres of land in Southern Wisconsin, five acres of it plowed, fenced and planted to wheat. The two-room log house had one room above the other and had no windows, but it looked good to these people who had worked in a factory or as tenant farmers in England with no hope of ever being able to own any farm land. John and Elizabeth Gray, had good crops, built a better house, raised six children and lived on the farm until they retired to live in the village that had grown up a few miles away.

Both of my parents taught in district schools to help pay for more education, father at medical school (Northwestern) and mother at a normal school. Their biology instruction must have appealed to them for they both made quite large collections of wild flowers carefully mounted, named with all the required data and so well preserved that they were welcomed by the Botany Department of the San Diego State College to add to their herbarium a few years ago. One wonders how many of the flowers in these collections, made in 1875–6 could be found in the old neighborhoods now.

The family moved to National City, a small town south of San Diego, California in 1887 on account of Dr. Johnson's health. In the milder climate of southern California he practiced medicine until he was nearly 80 years old.

Dr. Johnson entered the National City grade school in 1887 and graduated from the National City High School in 1897. She says about these years:

"Classes were small, two grades in a room with a total of 35 to 40 students. High school student body occupied one large room, there were two teachers, later two more added. A small room off the large one served as an additional recitation and laboratory room for setting up experiments for physics and chemistry. Everyone took the one course offered as there were no choices. There were six graduates in 1897 and all but one went on to higher schools and all competed there with marked success.

In the 9th grade we studied Gray's Botany. Other than this I do not remember that we were offered even any courses called Nature Study. But an important part of the four young Johnson's education was the exploration and the 'field work' carried on in our play time. There were more vacant lots than fenced ones in the town so we could roam quite freely without bothering anyone. Encouraged by, but not accompanied by our parents we found trap-door spiders, scorpions, tarantulas, wild flowers, California Holly, and brought specimens home to an appreciative audience. We dug clams and watched crabs, fish, and birds on the bay shore, only a few minutes walk from home. We went on family picnics to near by ocean beaches and collected shells and learned to know many of the marine animals.

Other extra curricular items were private drawing and painting lessons in the summer and photography. When I was in the second year of high school I bought a 4 x 5 camera. At that time there were probably not more than two other amateur photographers in town so I was kept busy taking pictures of pets, children, houses, etc. for neighbors and friends. One had to do all one's own finishing. The price I charged paid little more than expenses but I learned much from the experience. The hobby has been useful in many ways, in teaching, and in retirement."

Graduation from San Diego State Normal School 1901

Two years following high school graduation were spent taking some English and Latin courses not given at the school before —and in photography. Normal School at that time offered two years of work beyond high school and prepared for grade teaching. Here I enjoyed my first formal course in biology and used the compound microscope.

Grade Teaching

South San Diego district. 1901–1902. From seven to ten students in almost as many grades, 1st grade through 8th. Many changes as families moved in and out of the area.

Palomar district. 1902–1903. From five to nine students, 2nd to 9th grades. Two families moved off the mountain; three students graduated from 9th grade left two so the district merged with another the next year.

Los Angeles City Schools. 1903–1904. Grades 7 and 8, 2 and 3, 4 and 5. The area served by Main Street School was changing from country to city and as each new class room was added, the older teachers had first choice. The variety that fell to me gave me good experience.

University of California 1904–1912

B.S. 1908. Majors: Mathematics and Zoology.

M.S. 1909. Major: Zoology. Was granted a secondary teaching credential: Mathematics and Zoology.

Ph.D. 1912. Major: Zoology. Minor: Botany.

Summer of 1907, between junior and senior years: Assistant working under the direction of Dr. Wm. E. Ritter at the La Jolla laboratory of the Marine Biological Association. During junior and senior years in spare time made dissections of Ascidians and pencil sketches of same for Dr. Ritter. These helped him speed up his identifications of the numerous specimens collected on various expeditions and left with him for naming.

1909–1910. Research Assistant at La Jolla laboratory of the San Diego Marine Biological Association. Dr. Ritter was director of the laboratory and during this period the Association became the Scripps Institution for Biological Research and moved out from the small lab in the La Jolla park to the newly completed laboratory building about two miles farther north. Growth of the institution and expanding of its program led later to the change of name to the present Scripps Institution of Oceanography.

January 1911. Continued work toward Ph.D. at Berkeley. For one semester, was Assistant in Zoology under Dr. Harry Beal Torrey.

1911–1912. University Fellow in Zoology while completing work for the degree.

Titles of Theses

Master's: A Quantitative Study of the Development of the Salpa Chain in *Salpa fusiformis runcinata*. University California Publication Zoology, vol. 6, no. 7, pp. 145–176. 15 figs. in text. 1910.

Ph.D. The Control of Pigment Formation in Amphibian Larvae. University California Publication Zoology vol. 11, no. 4, pp. 53–58, pl. 1, 1913.

High School Teaching

Pasadena High School 1912–1921, except for spring semester of 1916 and fall and spring semesters of 1920–21 when I was on leave to work on the seashore animal book.

San Diego State College Teaching

1921–1946, except for spring semester of 1931 when I took time off for a trip along the southern route to Florida. (There were no sabbaticals in those days, just time off from both teaching *and* salary.)

Publications include two contributions to the California State Department of Education *Science Guide for Elementary Schools* series. The writer recalls the excellence of these publications by a number of noted California science teachers. They have, for the most part, long been out of print. However, Dr. Johnson's *West Coast Marine Shells* has proved so popular with teachers, visitors to beaches, and museum classes, that it has been reprinted four times. Dr. Johnson was co-author (with Robert D. Harwood, Dorothy R. Harvey, and James E. Crouch) of *How Living Things Get Food,* a now out-of-print Science Guide. Dr. Johnson was also junior co-author with Dr. William E. Ritter of "The Growth and Differentiation of the Chain of Cyclosalpa Offinis Chamisse," *Journal of Morphology,* vol. 22, no. 2, pp. 395–453. Dr. Johnson's most popular publication has been *Seashore Animals of the Pacific Coast* (junior co-author Harry James Snook) published by The Macmillan Company 1927 and reprinted in 1935. Dr. Johnson describes her experience in publishing this book:

"Out of print again since about 1938. Much work has been done on the revision by Mr. Snook and myself but much more still remains to be done.

"The junior author was also a teacher in the Pasadena High School and later he and his family moved to Stockton where he was head of the biology department for many years. After the many summers spent working on the book, Mr. Snook served for years as naturalist in Stockton's Summer Family Camp and introduced hundreds of his fellow townsmen to the flora and fauna of the Silver Lake region. He was a teacher who could inspire respect for and stimulate interest in biological science. He passed away in 1958.

"Work began on the book in 1915 while Mr. Snook and I were both teaching biology at Pasadena, where the policy was to give as much laboratory and field work as possible with as much living material as we could furnish for study. This meant many collecting trips to gardens, to the beaches, and to the mountains to supply the needed material in attractive condition.

"Available books on marine invertebrates dealt with Atlantic coast species almost entirely so we felt the need for a book with scientific names for our species and information on their habits and distribution. Urged on by our efficient and beloved department head, Miss Mabel Peirson, Mr. Snook and I undertook the job of combing research papers, quizzing research workers, collecting by the 'dawn's early light' and gathering material on the invertebrates most commonly found on the western beaches. We were given laboratory space at the Scripps Institution at La Jolla where we worked for about six weeks each summer until 1921 when we worked at the Friday Harbor Marine Laboratory. Meanwhile I had taken time off from teaching to make collections and photographs or sketches of living material at a number of points along the central coast and had met marine biologists who were eager to help speed the book on its way and were most helpful. We were aiming for a picture book of the animals with a minimum of word description and as much of life history and habits as we could learn. The era of color photography, fast film and handy sized cameras was far in the future but we managed to get a photograph, outline drawing or a color sketch of nearly every species common enough to be included. We were thinking of high school students as we wrote and the book has been sought by high school and college students, at marine stations, and by beach combers of all ages."

Membership in organizations include: Member and Fellow of American Association for the Advancement of Science; member and Fellow of the California Academy of Sciences; member and Fellow of the San Diego Soc. Natural History; member San Diego Aquarium Society, San Diego Fine Arts Society, San Diego Zoological Society, Sierra Club, Audubon Society, Cooper Ornithological Society, National Parks Association, Biological Photographic Association, University Women's Club, National

Education Association (Life), National Association for Research in Science Teaching (Life), and Alpha Delta Gamma Alumni. She is listed in *Leaders in American Science* and *American Men of Science.* Dr. Johnson has served on numerous San Diego State College Committees, a number of times as Chaiman.

Travel includes much of the Rocky Mountain region, both the United States and Canada, and other parts of the United States.

Dr. Johnson briefly summarizes her teaching philosophy as follows:

"The foregoing life history notes suggest the educational ideas evolved during the years of teaching. They sound much like the conclusions of many others who have worked on the same problems. In the high school teaching a number of us had sections of the same course and consulted together as to procedure with the head of the department, a Cornell University graduate, who helped set the direction. Many of the usual experiments and laboratory directions for the study of animals were thrown out entirely and other material substituted. The interests of the students decided the approach together with the effectiveness of the experiment or the materials to be used in teaching the point. We used living plant material or study rather than prepared slides, (at least in the first approach) and living animals in preference to stiff, preserved ones, particularly in the case of the lower phyla. The course was a study of live things with an abundance of living material but including some dissection later which, by this time the students did not find too revolting. Apparently they had become accustomed to us and trusted us.

"Later, in college teaching, the same general plan was followed. The students who had not taken a biology course in high school and who were preparing to teach in the grades had need for the same sort of review (and extending of their view) of life processes and of living things.

"Educational motion pictures supplemented and prefaced field trips and made the animal study more real to them. This was especially true after I made a series of motion pictures and some stills in color of our own beaches and the animals characteristic of the different shore situations. The film on the daily life of the fiddler crab was the favorite.

"This interest in many cases makes the student more receptive and he takes more interest in the whole subject of biology.

"Biographies of eminent biologists seemed to be of particular interest to students and I have found them of special value not only in teaching the special problem being solved but also to help them understand better the scientific method, the meaning of truth and devotion to the solution of a worth while problem."

Former students acclaim Dr. Johnson as an inspirational, thoroughly prepared, and an always interesting classroom teacher. Much of her classroom work was based on her long and first-hand experience with the materials under discussion. The writer never had the good fortune of meeting Dr. Johnson personally but we have long known about her fine classroom work and publications.

A member of N.A.R.S.T. since the mid-thirties, Dr. Johnson never found it possible to attend an annual meeting. Now a Life member, she has never wavered in her professional loyalty to the organization, despite the fact she could never attend N.A.R.S.T meetings. Such professional loyalty is worthy of emulation by many of our younger and, unfortunately, more mercenary-minded would-be science education leaders.

Now in retirement at her home at 4647–55th Street, San Diego, Dr. Johnson finds much to occupy her time and interests. Presently she is engaged in a revision of her *Seashore Animals of the Pacific Coast.* So to an outstanding classroom teacher of science and a teacher with the highest professional ideals is presented the Fifteenth Science Education Recognition Award.

CLARENCE M. PRUITT

THE SCIENCE TEACHING IMPROVEMENT PROGRAM OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: AN EVALUATION

JOHN W. GUSTAD
University of Maryland, College Park, Maryland

DURING the years 1956 through 1958, the American Association for the Advancement of Science (AAAS) conducted, as part of its educational program, the Science Teaching Improvement Program (STIP). A major part of that program was the study of the use of science counselors [1, 2]. The program was under the direction of Dr. John R. Mayor, Director of Education of AAAS. The present writer was invited to participate in the program to serve as an evaluator.

Briefly, STIP involved a study of the effects of science counselors. Four state universities, those of Nebraska, Oregon, Pennsylvania, and Texas, agreed to participate. With funds provided by AAAS, each one hired a staff including a coordinator and two (2) science counselors. The latter were selected as experienced science teachers. Typically, one was a specialist in the biological sciences, the other in the physical sciences and mathematics.

In each area, center staff members selected a number of high schools for work. These were selected on the basis of size, location, and a number of other variables that insured broad representativeness of the sample. STIP staff members then devoted two years to working with the teachers and principals in these schools in a wide variety of ways. These are described in the references cited above, and they will not be dealt with here except as they relate directly to the evaluation.

The ultimate evaluation of an enterprise such as the Science Teaching Improvement Program (STIP) must necessarily rest on its effects on students. This sort of evaluation would require a number of conditions which could not be met in the framework of the present, exploratory program. For one thing, extensive assessment of students, done before as well as at several points after exposure to the program, would be needed in order to measure effects. A control group, made up of students with similar characteristics but not effected by STIP, would also be required. Finally, the scope and intensity of the program would have to be markedly increased in order for there to be a reasonable basis for expecting measureable results. Two counselors for an entire state, even when they worked principally with approximately a hundred teachers, is simply not enough staff to produce such effects. STIP was exploratory, and the evaluation had to be at the same level.

STIP was set up to work with teachers on the assumption that effects on student learning of science and mathematics would be brought about through improved teaching methods. It therefore seemed that the reactions of the science teachers (as well as the reactions of certain others in a position to observe the program in operation) might well serve as an informative and reasonable basis for the evaluation of STIP. Accordingly, the evaluation to be reported below was based on the opinions of three groups: (1) science teachers who had participated in the program; (2) other participants such as principals, superintendents, librarians, guidance teachers, and university faculty members; (3) the STIP counselors. It was felt that fairly detailed analyses of STIP by these groups would provide a balanced and sound basis for evaluating the program.

Data for this evaluation were collected by two means. First of all, questionnaires were developed, one for teachers, another form for the other participants. Secondly, interviews were conducted with a small sample of participants. These interviews were of approximately an hour's duration and were conducted by experienced clinical and counseling psychologists.

In April, 1958, questionnaires were distributed. A total of 700 questionnaires were sent to participating teachers. Of these, 636 useable completed questionnaires were received, a 91 per cent return. Questionnaires received from non-teachers were, for the most part, not useable since a large number of items were omitted by many of these respondents. It was therefore decided that the interviews would be relied on exclusively to provide information on the reactions of this group to STIP.

Interviews were conducted during May and June of 1958. A note of gratitude is due to the interviewers who agreed to take time from their crowded schedules to assist in the evaluation of STIP. Interviewers and their universities were: Dr. Marshall R. Jones, University of Nebraska; Drs. Norman D. Sundberg and Charles Warnath, University of Oregon; Drs. Lester P. and Pearl H. Guest, Pennsylvania State University; Dr. Gordon V. Anderson, University of Texas. Each state provided fifteen interviews. Ten of these were with teachers, five of whom had expressed very positive feelings about STIP, five of whom had expressed some reservations about it. The other interviews were conducted with principals, superintendents, university faculty members, librarians, and guidance counselors.

The first section of this report and the one of major concern will deal with teachers' reactions. In addition, certain characteristics of teachers, insofar as these are related to their opinions about STIP, will be noted. The second section will present the reactions of the non-teachers group. Finally, Counselors' evaluations will be described.

TEACHERS' REACTIONS TO STIP

As a first step in analyzing the returns, those sections dealing with the direct evaluation of STIP were scored by assigning numerical weights to the item responses and summing these. These scores were then distributed and divided into three groups: a very favorable group, a moderately favorable group, and a least favorable group. Table I contains the numbers of men and women teachers in each state falling into each of these groups. It is apparent from this table that there were state and sex differences in teachers' evaluations of STIP. Men teachers in Pennsylvania and Texas and women teachers in Oregon and Texas appeared most frequently in the top group. At the other end, men teachers in Nebraska and Oregon and women teachers in Nebraska and Pennsylvania were most heavily represented.

There were nineteen items on which teachers were asked to rate STIP. Mean response positions (where weights ranged from 1 to 4) for the various groups are contained in Table II. The differences among states and between sexes are perhaps more striking than are the general trends. Examination of this table would appear to support the conclusion that reactions to a program such as STIP are quite variable and individualistic. It is known that each group of

TABLE I

DISTRIBUTION OF TEACHER RESPONDENTS ON GENERAL SATISFACTION WITH STIP

	Score Ranges											
	0.0–2.3				2.4–2.9				3.0–4.0			
	Men		Women		Men		Women		Men		Women	
States	N	%	N	%	N	%	N	%	N	%	N	%
Nebraska	30	43	15	49	26	37	11	36	14	20	5	16
Oregon	41	49	10	23	30	36	11	25	13	16	23	52
Pennsylvania	21	29	6	32	25	35	6	32	26	36	7	37
Texas	27	36	7	17	22	29	11	27	26	35	23	56

TABLE II

MEAN RESPONSES (DECIMALS OMITTED) TO ITEMS DEALING WITH STIP ACTIVITIES AND EFFECTS

	Low								Middle								High							
	Nebr.		Oreg.		Penn.		Texas		Nebr.		Oreg.		Penn.		Texas		Nebr.		Oreg.		Penn.		Texas	
	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W
3a	15	23	15	10	16	20	18	20	23	28	25	30	27	24	26	32	30	33	29	28	30	28	30	29
b	25	21	21	18	26	30	28	40*	29	27	30	32	32	33	30	31	35	36	36	37	37	43	39	37
c	23	17	21	16	17	15	22	13	30	30	29	33	25	30	28	29	35	36	36	36	31	27	35	35
d	21	21	22	25	22	27	26	15	28	31	32	35	27	37	24	29	34	36	36	36	37	33	36	37
e	19	12	18	23	15	20	21	20	26	30	24	22	19	30	21	21	31	37	33	31	31	28	33	35
f	14	14	16	17	15	25	20	20	29	32	24	23	22	26	26	22	28	36	33	29	31	28	35	34
g	17	20	22	15	20	20	20	20	21	28	23	30	24	20	28	25	30	40	30	35	32	30	32	33
h	12	15	11	10	14	—	30	10	24	30	19	28	23	17	22	28	25	35	31	30	29	25	31	29
i	16	18	20	15	21	17	22	23	22	30	24	33	26	25	30	28	33	33	30	32	31	31	33	35
k	16	16	17	20	16	17	14	10	25	21	22	21	26	28	25	21	34	38	25	24	35	34	33	22
l	17	18	17	13	22	24	21	20	28	27	26	28	30	32	27	26	34	40	18	33	37	33	34	33
m	16	16	15	10	15	13	16	—	24	24	20	35	24	25	25	29	28	35	31	29	26	24	32	32
n	16	22	15	20	18	27	24	17	22	20	21	35	30	13	28	33	29	33	28	23	37	38	32	30
4a	22	20	21	23	24	18	25	25	31	26	30	28	30	30	27	30	35	38	37	32	31	35	30	36
b	14	11	16	—	15	10	17	25	21	22	26	23	22	18	19	24	26	30	28	35	27	32	31	26
c	18	20	21	20	21	18	20	10*	26	26	30	29	28	27	24	24	32	40	35	35	33	36	32	25
d	18	17	22	23	22	10*	14	—	21	27	30	35	22	20	18	17	29	40	31	34	29	38	34	28
e	28	22	20	28	31	33	23	20	33	33	28	30	38	37	30	35	39	40	36	37	40	40	38	38
f	11	11	13	20*	16	13	13	10*	14	30	23	17	21	10	20	13	35	40	30	37	29	33	27	33

STIP Counselors worked out its own preferred *modus operandi* in terms of perceived needs and staff strengths and interests. Pattern differences, state to state, might therefore be expected since the programs varied considerably.

Listed below are the nineteen items to which the teachers responded (through a clerical error, there was no item "j"). The first group of items are concerned with effects of STIP:

a. Stimulate greater student interest in science.
b. Provide you with new information about content for teaching.
c. Provide you with new ideas about teaching methods.
d. Stimulate your interest in your own field.
e. Help your superintendent better to understand your problems.
f. Help your principal better to understand your problems.
g. Create added interest in science in library staff.
h. Help guidance counselor to understand science better.
i. Help you in developing a better library.
k. Provide better opportunities for you to make contacts with university staff members in your field(s).
l. Help you to provide more information about science to students.
m. Help interest more students in careers in science.
n. Help stimulate student interest in such activities as science fairs, etc.

There were, in addition, six items that dealt with the methods used by the Counselors in attaining their goals. These were:

a. Individual conferences.
b. Class visits by STIP Counselors.
c. Group visits.
d. Instructional sessions.
e. Providing teachers with printed materials.
f. Having resource person speak to your classes.

In order to obtain data useful in interpreting these evaluations, items were included in the questionnaires and the interviews dealing with both personal history and working conditions. A substantial number of relationships were noted, but there was no clearly discernible pattern. Rather, there were state and sex differences noted in almost every case.

Age is a good example. By and large, the women teachers were substantially older. Men, with families to support, tend either to move into administrative posts or to leave teaching for more lucrative positions. Age was related to over-all evaluation in several ways. In Pennsylvania, the older women were more positive toward STIP whereas in Texas, the reverse was true. Among the men, there were curved relationships (largest group falling in the middle, or moderately favorable, category) in Oregon and Texas. In Pennsylvania, the younger men were more favorable while the reverse was true in Texas.

Teachers' fields of major and minor study, both graduate and undergraduates, yielded the same complex set of relationships. There was no readily discernible pattern but rather a large number of varied relationships. It is clear that it would be impossible to predict response to STIP on the basis of a knowledge of field of study, but the relationships found suggest many intriguing hypotheses. One thing was noteworthy: a very substantial number of these science and mathematics teachers reported major study in the field of Education rather than in a science field. This datum is interesting when related to a question in the interviews to which many teachers responded by saying that they felt a great need for further training in the science fields.

Teaching experience did not appear to relate to attitude toward STIP. What relationship there was suggested that the very new and the relatively senior teachers reacted less positively than did those in the middle years of experience.

Professional group affiliations yielded some interesting replies. Professional education societies account for the majority of such memberships. However, science and science teaching groups were more often cited as being the most helpful. Other sources of information suggest that one major effect of STIP has been to get many teachers to join scientific and science teaching groups.

With respect to working conditions, there was a general trend for teachers in smaller schools to be more favorably disposed toward STIP. This may be due to the fact that larger schools have, on the average, better teaching facilities.

Availability of separate laboratory facilities was positively related to over-all evaluation among the men but not among the women. Far fewer women teachers reported having such separate laboratories, an interesting and provocative difference. This predominant lack of separate laboratory space probably accounts for the lack of a correlation among the women.

Rated adequacy of laboratory facilities was related to over-all evaluation, at least among the men (see above). The relationship between evaluation and rated adequacy was negative. That is, the most favorably inclined teachers rated their laboratory facilities lowest. On the other hand, rated quality and quantity of classroom teaching aids did not appear to be related to evaluation of STIP.

Number of hours per week in teaching and laboratory supervision was not related to attitude toward STIP. By and large, the range was very narrow although there were some differences among the states. Teachers in Oregon and Pennsylvania had somewhat heavier teaching loads.

Class size yielded the same sort of results. The range was quite small, too small to permit the emergence of distinctive trends toward a relationship. By and large, classes ranged from 25 to 30 students.

With respect to the adequacy of the library facilities, there was a generally positive relationship between these ratings and total evaluation of STIP. This is interesting in light of the many comments made in the interviews about the benefits derived from the traveling libraries. In Pennsylvania, where this activity was emphasized, the relationship was negative with the more satisfied (men) teachers rating their library facilities lowest. The relationship for the women teachers was by no means as clear or consistent.

Certain areas dealt with only in the interviews are of interest. Asked about the preparation of students for science study, there were differences only among the states, not between the most and least satisfied teachers. In Nebraska and Texas, the teachers most favorable to STIP rated their students' preparation high; the reverse was true in Oregon and Pennsylvania. With regard to student motivation, teachers least favorable to STIP consistently rated student motivation higher. In the interviews, one of the aspects of STIP most frequently cited was positive effects on student interest and motivation.

By and large, the teachers felt that the support they were receiving for science teaching was fairly good. This is surprising in view of the discontent about such things as teaching aids and laboratory facilities. By and large, teachers seem to feel that their principals and superintendents understand the problems of science teaching. Such feelings did not appear to be related to attitudes toward STIP, perhaps because the range was rather narrow.

Asked about their own preparation for science teaching, some interesting relationships with evaluation of STIP were noted. In Nebraska, this relationship was positive (better satisfied teachers rating their own preparation high); in Oregon and Pennsylvania, on the other hand, the relationship was negative, the reverse of that found in Nebraska; in Texas, there was no relationship. Considering the group as a whole, the most satisfied teachers tended to feel less adequate in their preparation.

Taking the group as a whole, the majority expressed a desire for more training. They were especially eager to obtain further training in the basic sciences and mathematics; courses in teaching methods were very rarely mentioned. Chemistry, physics, and mathematics were the most often cited fields in which more study was needed.

Asked how many contacts they had had with STIP Counselors, there was a generally positive relationship with evaluations.

That is, teachers who had had the most contacts were, in general, the most satisfied with STIP. Group and individual contacts yielded the same patterns in this regard. On the other hand, examining the results to the question of how many contacts they would have *liked,* there was almost no discernible relationship with evaluation. Virtually all teachers expressed a wish for substantially more contacts. The interviews brought this out clearly. Most teachers, regardless of their total evaluation of STIP, felt strongly that it should be continued with more Counselors so that they could have more contacts with them. Many also felt that Counselors should be provided in non-science fields.

Asked in the interviews what STIP had done for them, the teachers' answers varied widely. Certain classes of effects, apparently unrelated to evaluation of STIP, could be identified: (1) providing materials, such as demonstration materials, information about new methods, etc. (2) Help with curriculum organization. (3) Improved morale. Simply having interested and able individuals with whom they could discuss their problems seemed to have given many teachers renewed interest in their work. (4) Improved understanding, not only by administrators but on the part of other teachers and university faculty members. (5) Intellectual stimulation. Many teachers appear to have been feeling a kind of intellectual isolation which STIP helped to reduce.

Asked what STIP *ought* to do, the most common reply was "more of the same." As noted above, most felt that there were not enough Counselors to go around. Another common suggestion was that STIP should be extended downward into the elementary grades, perhaps into non-science areas as well. A third common response was that STIP might well concentrate more on the problems of evaluation. Teachers seemed to feel a need to know better how they were doing.

Finally, the teachers were asked for their suggestions about how to improve science teaching. Three classes of responses could be identified. Commonest was the need to improve the quality of teachers. Such a recognition of their own responsibilities and central positions in teaching is an encouraging sign. Secondly, many teachers felt that sectioning students by ability levels would help, freeing the teachers from the problems of having a wide range of abilities in the same class. Finally, improved incentives (including even premium pay for science teachers) were mentioned often. Deeply attached in most cases to science teaching, they are also aware that government and industry are competing strongly for available teaching talent and that schools have to meet this challenge.

OTHERS' REACTIONS TO STIP

As noted, the interviews were relied on for information about the reactions of principals, superintendents, librarians, guidance counselors, and university faculty members to STIP. Since only twenty such interviews were conducted, the comments below cannot be considered definitive. However, their consistency argues for their validity. As a group, these individuals were highly favorable to STIP, hope that it will be continued.

The first item of general interest asked what these individuals felt that STIP had done for them and a number of related subquestions such as satisfaction with these activities, suggestions for changes, qualification of STIP Counselors, etc. University faculty members, on this item, felt that STIP had made a very substantial contribution. Their comments fell into three general groups: (1) improved communication among teachers. This relates to the professional interaction and stimulation mentioned above, gives teachers the opportunity to gain new ideas and perspectives. (2) Better liaison with the universities. Understanding the problems of science teachers was seen as a need of university faculty members who might thereby be enabled to improve their own teaching. (3) Stimulation of teachers. This related to the first item above in that these professors felt that STIP had stimulated the teachers to better efforts, to seeking for self-improvement, and to working out better ways of presenting their subject matter to students. All of these faculty members were quite satisfied with STIP in its operation. None had any specific suggestions for improvements but felt that STIP should be continued and, if possible, expanded. They agreed that the STIP Counselors were very well qualified. One noted that some older teachers, described as "war-horses" occasionally resented the younger Counselors and questioned how these youngsters could tell them anything. These were, however, a small minority, and the faculty member obviously disagreed with their point of view. Faculty members were somewhat less sure of what STIP was supposed to be doing, at least at the beginning, but they learned quickly. One man had been running a similar program just for his own department and welcomed STIP's coming along.

The administrators (principals and superintendents) also appeared to react quite favorably to STIP. On this same item, however, they seemed to react to more detailed and immediate problems such as textbook selection, laboratory planning, teacher improvement, study guides, etc. They also felt that STIP had stimulated and motivated the teachers and had made them, the administrators, much more aware of the problems and needs of science teaching. Almost all of them expressed considerable satisfaction with STIP, would like to see it continued. Their commonest suggestion for improvement was to provide more Counselors so that teachers might have more time with them. The administrators felt that the Counselors were both well trained and accepted by the teachers. Interestingly enough, a substantial proportion of these individuals expressed no need for more Counselor contacts for themselves. They felt at the same time that the teachers should have more. Apparently, the Counselors made it a point to inform the administrators of the program's purposes, because they seemed to be well aware of what it was designed to do.

The other respondent group worked in the librarian and guidance counselor areas. Their reactions were very much like the teachers, not at all surprising since all of them were part-time teachers. However, their reactions to STIP were also conditioned by their special assignments. Receiving books for the library and materials related to science careers were seen as especially helpful. All were well satisfied with STIP although there were was agreement that more visits would have been desirable. There were no real criticisms but a feeling that more could have been done had there been more Counselors. As they saw it, the Counselors were well accepted by the teachers and seemed to be well qualified.

Two other areas dealt with in the questionnaires are of interest: estimates of STIP's strong and weak points and ideas for the improvement of science teaching. Regarding the strong and weak points, the university faculty members seemed to feel that stimulating teachers and improving the communication lines among teachers and between teachers and university staff members were the major strong points. The only weakness they saw was inadequate time due to too few Counselors.

The administrators, as in the previous section, were somewhat more impressed by concrete and specific things such as bringing equipment, setting up demonstrations, conducting in-service training, and the like. They also felt that the effects on teachers—improved morale, greater interest in teaching and in self-improvement—were important. Their major concern about STIP was that the contacts were too brief and occasional. They would have liked more Counselor time.

Those in the librarian-guidance counselor group felt that teacher effects were most important. Like the others, they felt that more time would have helped the program to do more.

Finally, the groups were asked for their suggestions about improving science teaching in the schools. The university faculty members cited improved teacher pay and raised standards as important items. They also felt that students should get more laboratory time and that teachers should be better prepared. In this, they were not seemingly critical so much as sympathetic to the problems of the secondary school teachers. Nevertheless, these men, operating at a high level of scholarship and research, recognized a real need for better training for teachers.

The administrators emphasized several points. They, too, felt that the great need was for better trained teachers. By this, they meant more training in the subject matter being taught. Several said that two or three courses in college is not enough to qualify a teacher to deal with rapidly expending areas of science. They also felt that better facilities are needed, especially laboratories. Incentives and stimulation for teachers was another area. This included better facilities, better pay, and opportunities to get further training. Programs like STIP were seen as excellent for motivation and stimulation. The administrators also thought that homogeneous grouping of the students would lead to better teaching.

Finally, the librarian-guidance group emphasized better equipment especially laboratories, homogeneous grouping of students, and better preparation for teachers. Their responses were, in general, like the teachers'.

COUNSELORS' EVALUATIONS

Two kinds of ratings obtained from the Counselors were of interest. First of all, they were asked to rate the effectiveness of their own work with the teachers. Table III summarizes these ratings (where the scale valued ranged from 1 to 5). In general, the Counselors felt that they had done a reasonably good job. Moreover, the ratings tended to improve through time. This is not an unexpected result, of course. There were some interesting differences in average self-ratings among the four groups of Counselors with the Oregon Counselors most satisfied and the Nebraska Counselors least satisfied with their work. There were no consistent patterns of differences as far as rated effectiveness in work with men and women teachers was concerned. It is interesting to compare Counselors' ratings in this table with teachers' over-all ratings contained in Table I. It is apparent that there are some differences of opinion between the teachers and the Counselors.

Next, the Counselors were asked to rate effects in certain areas. In addition, an indirect measure of relative emphasis in

TABLE III

COUNSELOR SELF-RATINGS OVER TIME (MEANS)

	Semester of STIP				
State	I	II	III	IV	Overall
Nebraska					
Men	2.3	2.8	3.0	3.5	3.1
Women	1.9	2.8	2.9	3.2	2.8
Oregon					
Men	4.0	4.1	4.3	4.4	4.4
Women	3.9	4.4	4.3	4.2	4.4
Pennsylvania					
Men	4.0	3.9	4.1	4.2	4.1
Women	3.5	4.1	4.0	4.3	3.9
Texas					
Men	2.1	2.6	3.3	3.5	3.1
Women	2.3	2.8	3.2	3.5	3.1

TABLE IV

COUNSELORS' RATINGS OF EFFECTIVENESS AND EMPHASIS BY AREA

Area	Nebraska Men A*	Nebraska Men B†	Nebraska Women A	Nebraska Women B	Oregon Men A	Oregon Men B	Oregon Women A	Oregon Women B	Pennsylvania Men A	Pennsylvania Men B	Pennsylvania Women A	Pennsylvania Women B	Texas Men A	Texas Men B	Texas Women A	Texas Women B
1. Teaching techniques	3.2	86	3.0	97	4.1	85	4.0	79	4.0	60	3.8	46	3.1	97	2.7	95
2. Curriculum	3.1	71	3.1	77	4.2	97	3.9	86	4.2	64	4.1	43	3.3	92	2.9	95
3. Phys. equip.	2.9	31	2.3	18	4.4	53	4.0	10	4.1	50	4.2	36	3.0	91	2.4	96
4. Tchg. materials	3.1	55	3.0	64	4.4	90	4.3	96	4.2	91	4.2	100	3.2	97	3.1	86
5. Personnel	2.5	14	3.3	8	4.3	87	4.4	90	4.3	57	4.1	41	2.8	96	3.3	87
6. Professional activities	3.7	29	3.7	8	3.7	72	4.3	79	4.0	80	3.8	70	2.8	90	2.4	100
7. Incentive programs	3.1	13	3.2	13	3.9	42	3.6	17	4.1	90	4.0	85	3.2	85	2.9	87
8. Subject matter	3.0	25	2.9	36	4.2	87	4.0	83	4.1	70	4.1	62	3.2	100	3.3	94
9. Other	2.8	30	2.0	3	5.0	100	—		—		—		—		—	

* A — mean ratings.
† B — Estimate of degree of emphasis on area.

the various areas was developed. These ratings and estimates of emphasis are included in Table IV. In general, the Counselors in Pennsylvania and Oregon rated their activities as more successful than did the Counselors in the other two states. Such over-all ratings are less meaningful, however, than are the ratings in the specific areas since each state tended to emphasize different activities and areas of work.

In Nebraska, curriculum development and teaching techniques were most heavily emphasized. Interestingly, the area of greatest rated success was that concerned with professional activities (interesting teachers in joining various science and science teaching societies), an area of relatively slight emphasis. The Nebraska Counselors felt least successful in achieving effects on administrators and in improving the physical facilities (at least for the women teachers).

In Oregon, least emphasis was placed on improving physical facilities and in fostering science incentive (science fairs) programs. These Counselors felt that they had had their greatest success in the personnel (administrators) and teaching materials areas.

In Pennsylvania, the differences in emphasis were less between areas than between sexes. Apparently, more was done with and for men teachers than for women. At the same time, two areas, science incentive programs and teaching materials were more heavily emphasized than others. The interviews brought out further information on this point. Teachers commented very favorably on the highly developed and effective system used to get for them either teaching materials or information about sources for such materials.

Contrary to the prevalent stereotype, the Texas Counselors were the most modest of all with respect to ratings of their own success. It would not appear to be a case, as was true in Mr. Churchill's opinion about Mr. Attlee, that they had much to be modest about. Table I suggests that the teachers with whom they dealt regarded their efforts highly. These Counselors tended to spread their efforts widely over all areas of activity. Areas of greatest rated success were subject matter, science incentive programs, personnel, and teaching materials.

CONCLUSIONS ABOUT STIP

Recognizing that observer opinions are not to be considered as definitive criteria but maintaining nevertheless that, for an exploratory, pilot program such opinions form the soundest base for evaluation, it seems fair to say that STIP was, in the eyes of its beholders, a very successful enterprise.

The teachers, who were the primary objects of this program, expressed generally very positive reactions to it. Opinions expressed in the interviews were especially laudatory. The only major deficiency noted was that there were not enough Counselors to do all of the things that needed to be done. Almost universally, the teachers wanted the program continued and with more Counselors. Having been involved in a good thing, many of them even expressed the feeling that such a program should be extended downward to the elementary schools and outward to other, non-science areas.

Particularly in reading the interview protocols, one gets the feeling that STIP perhaps had its greatest effects in two areas: morale and intellectual stimulation. Teacher morale is certainly one of the most critical ingredients in the educational system. Without it, teaching will become routine, mechanical, and dull. With it, there is hope that, despite frankly admitted shortages in teaching equipment and laboratory facilities, too large classes, heavy teaching loads, and low pay, students may learn to feel the excitement of learning about science.

Others who were in a position to observe STIP agreed, often being even more favorable to it than the teachers. Principals and superintendents, beset by numerous difficult problems, saw STIP as an invaluable aid to improving the quality of science teaching. Like the teachers, they hoped that STIP would continue and be expanded.

Seeking for correlates of the opinions, there was no common pattern that would permit one to predict very well where STIP would be best received. There were many correlates that suggest further study. In general, it may be that programs like STIP are needed most in the smaller, less well equipped schools in relatively isolated areas. However, responses from teachers in other settings were such that it would seem unwise to restrict STIP in any way. It seems to be widely needed. It was certainly deeply appreciated.

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TEN POINTS TO SCIENTIFIC SUPREMACY

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EVEN prior to the Sputniks, the United States had been, for many years, in short supply of science-trained college graduates: doctors, psychiatrists, engineers, medical technologists, nurses, science teachers, and research workers.

Whether the Sputniks have struck a fatal blow to United States' prestige is debatable; whether the seven Vanguard failures are a significant indication of our technological lag in world science is debatable. However, both of these events serve to emphasize a problem which has been with us for some years.

The problem now is, as it has been, two fold: (1) to determine means by which this nation can secure adequate numbers of science specialists and make the most effective use of their talents in order to achieve scientific supremacy; and, (2) to simultaneously provide the setting within a framework of world peace in which our scientific supremacy can further human well being.

Let us examine the factors which are inherent in the concept of scientific supremacy. *First,* if the United States were to be scientifically supreme, it would mean that there were adequate dollar resources made available to support basic and applied research. The President has indicated his intention, and Congress is rumbling, to the effect that such funds are about to be made available.

Washington has indicated that tax cuts are unlikely; while grants to science foundations, education, and the National Science Foundation are increasing. Industry is contributing actively to the effort and will increase its support to offer financially attractive arrangements to private institutions, foundations, and individuals. Plant expansion and increased emphasis on research and experimentation among the aircraft, automotive and electronic companies are encouraging.

The need for dollar resources is also felt in education, and recent Congressional support has been declared inadequate by leading teachers' organizations. There is a serious need for more higher education at the same time that costs of a college education are rising and student self-help dollars buy less today than they used to.

There is evidence, however, that there is an increased number of student scholarships available and plans have been suggested to help solve this aspect of the problem. For example, J. R. Cominsky, in the November 23, 1957 issue of *The Saturday Review,* wrote a suggestion for financing higher education based upon credit buying called "study now; pay later." This is a significant contribution to the solution of the problem, but it is not enough.

There are corollaries to Cominsky's plan. A specific company could interview promising high school graduates and make agreements with them in signed bonds by which the industry would pay the college costs of the student who would then be obligated to work for the company "x" number of years. During this time, the student would either repay the loan or the company would absorb the cost as a tax write-off. If the student were to decide not to work for the sponsoring company, he would be obliged to repay the loan plus interest.

In industry, this would tend to normalize the hiring procedure which, according to some reports of employees interviewing employers, is fantastic only as it emphasizes the gravity of the situation.

Similarly, the government could pay for the college education of prospective employees after a suitable bond agreement is signed, under which terms the student would either work for the government "x" number of years or repay the government in installments.[1]

This plan would require a calculated risk to be taken on the part of the employers regarding the reliability of any prediction as to the probable success or future desirability of a high school graduate four years later. There would also be some losses on bad bonds. However, the system presents a challenge to the enterprise of industry which cannot be overlooked in these critical times.

The *second* factor of the problem is: what kind of science teaching should we have if the United States is to be scientifically supreme? There are those [2] who maintain that a theoretical science course is unsuitable for the majority of average students and that the principles learned in a theoretical course have no practical value to the life adjustment of the average student. Then there are those critics of so-called

[1] Since this article was written, the government has evolved a plan which include state contributions to student loans.

[2] Thomas H. Briggs, "Letters to the Times," *The New York Times,* December 1, 1957, p. 8 E.

progressive education who believe that catering to the average student in a life-adjustment curriculum tends to create a mediocrity from which the better students may never recover. Others propose special classes for the better students in which advanced work would be covered according to the capacities of the students, while the average student under the best suggestions would receive block and gap courses.[3] Almost no one favors a watered-down curriculum to meet any student's needs.

It is this writer's belief that regardless of the organization provided to accommodate the course *content* to various levels of student abilities, the *method* of science instruction should be based upon problem-solving. For "All that science has learned, it has learned from hypothesis and experiment. The scientist learns from evidence, not from innate knowledge."[4]

Problem-solving must be utilized to help the child make immediate life adjustments and also to prepare the child for future choices of action he may make. There are those who believe that the methods of science are seldom if ever used to solve practical problems in ordinary life.[5]

However, at least one of the scientific methods has been applied to solving human relations problems.[6] Furthermore, problem-solving consists of providing the means for making intelligent choices and unless young people are taught to apply the methods of science to practical life problems, they probably will not know how to use them.

In reference to utilizing problem-solving to help prepare young people for future choices of action, undue emphasis must not be placed upon immediately observable behavioral changes or acts of *doing*. Consideration should also be given to the objectives of science education which will result in long-range attainments.

For example, one hears, in the field of education, the advice that there is no room for an objective of teaching unless the child *does something* in attaining the objective. "What does a child *do* when he appreciates?", is a question raised in considering appreciations as a suitable objective of education. The immediate answer of some educators is, "Nothing!"; hence, there is apparently no defensible position to be taken for the inclusion of appreciations in the objectives of education.

If agreement could be reached on the meaning of *doing,* perhaps appreciations would become more acceptable as a legitimate objective. Do we mean positive, overt behavior; and if so, does this eliminate negative overt behavior, such as avoiding harmful insects? Probably most teachers would agree that a negative avoiding response would be necessary for man's adjustment to his environment, and *consistent* with other objectives of education; hence, suitable for inclusion in the objectives of education.

The child who appreciates a story of scientific discovery may make a choice of behaviors at some future time. If the story helps the child project himself into the life of a respected scientist, there might be provided the stimulus for a youthful self-promise to become a respected scientist. Faced with a choice of directions to take years later, the child may make the choice as a result of this long-ago appreciation and pursue a life of science.

An inspiring story, observations of living things, the sensual gratification of beauty in nature, elicit emotional responses the total purpose of which is to satisfy some of the emotional needs of the individual. Is this strictly functional or fraught with behavioral utility? The answer, in the writer's opinion, is *yes,* if these things help

[3] Eric M. Rogers, "Letters to the Times." *The New York Times,* December 15, 1957.

[4] William S. Beck, *Modern Science and The Nature of Life.* Harcourt, Brace, and Co., New York: 1957, p. XII.

[5] Thomas H. Briggs, "Letters to the Times." *The New York Times,* December 1, 1957, p. 8 E.

[6] H. H. Giles, "Conflict Episode Analysis—A Tool for Education in Social Technology," *Journal of Educational Sociology,* XXVII (May, 1953), pp. 418–33.

a child make a better adjustment to his environment by either seeing his environment in a more acceptable light or by fortifying him to endure the unpleasant aspects a little better. If a pleasant thought intrudes upon a harsher one which might be destructive to his growth and development, then, it is submitted, this is justified.

It would also appear that there is a need for a broader concept of *functional* which would include an emotional response intended to help a child make a better adjustment (not necessarily with observable behavioral change) to his environment by changing his perception or reaction to it.

Third, assuming that organizational problems for classes of various abilities can be solved and assuming that the orientation of the science content would be twofold: (1) to teach science to those immediately able to produce creative advances, and, (2) to teach science to help all children adjust to their environments and instill long-range appreciations in them for overall planning, it is still not enough.

If the United States were to be scientifically supreme, whole new systems of thought will have to be taught. For example, "*The sequence of thought* which led Einstein to propose this effort *began with another imaginary situation* . . . the scene opens in an elevator ascending with constant acceleration through empty space, far from any gravitational field. This time some roving interstellar gunman impulsively fires a bullet at the elevator." [7]

In order to solve a problem Dr. Einstein, as shown above, directed his thought to an imaginary situation. He mentally grappled with possible solutions which were inherent in the responses of passengers on his imaginary elevator. The process by which Einstein projected his thoughts into imaginary situations, in order to solve problems, is one which ought to be identified, analyzed, and presented in its elemental form as part of the public school program of instruction.

The inclusion of such instruction in our public school programs is necessary if we are to gain the most from our human resources, particularly in time of national emergency. It is in this sense that reference is made to producing more Einsteins. *Einstein* is synonymous with a complicated thought process; hence, persons capable of extensive thinking in the abstract or individuals taught to deal with complex abstract situations may be considered *Einsteins.*

The relationship between Einstein's imaginary situations and practical problems, which educators expect children to learn to solve, is conceived as follows. A practical problem would first have to be defined as one which a child would be expected to experience and to solve from his own fund of knowledge and experience. If this definition is accepted, the process of thinking out the elements of a problem by projecting the mind into an imaginary situation may be applied, as well, to a practical problem which is a new experience to an individual. If the person has not previously lived through the same situation, the problem and its elements are, in effect, imaginary to the person at that time.

A recent personal experience may serve to illustrate the proposition. The Union of Burma Airway's Dakota taxied to the take-off mark and in a few minutes the plane was airborne. Mandalay slowly faded in the distance. As soon as the "No Smoking, Fasten Seat Belts" sign blinked off, Burmese men began attempting to light their cheroots with verying degrees of success. It was the height of the Burmese hot-dry season; consequently, upon boarding the plane, everyone had turned on his seat ventilator to full output. The cold rush of air from the ventilator made lighting up a difficult process.

It was interesting to note the ways in which different people tried to solve the

[7] Lincoln Barnett, *The Universe and Dr. Einstein.* New York: The New American Library, 1954, p. 95.

smoking problem. It was immediately apparent that some people on board either enjoyed burning matches or were not recognizing all of the factors with which they had to deal in order to solve the problem. For the purpose of illustration, let it be assumed that this was the first plane ride for the following people.

The first man lighted several matches and then *gave up his efforts.* The second man lighted a match, saw it blown out, *looked for the cause,* and found the cause to be the draft. He turned down the air-vent and successfully lighted his cheroot. The third man *recalled* the draft before attempting to light his cheroot and promptly turned down his vent output. The fourth man cupped the first match in his hands and was immediately successful. It may be assumed that the fourth man cupped his hands due to habit or due to the fact that upon opening his vent, he *anticipated* a future problem and provided for its solution without having to go through the mental process of recalling the open vent.

The obvious conclusion which may be drawn from the activities of the four men described is that different people conceptualize to different degrees. It is proposed, however, that the ability to conceptualize may be learned and educators should teach for the attainment of this ability. Williams James said, "We learn to swim in the winter and ice-skate in the summer."[8] From this one may infer that the ability to swim, which consists of integrating three sets of bodily movements, may be achieved after a person has analyzed each movement and integrated the three movements mentally. The process of projecting oneself into an abstract situation is practiced generally even if only in day dreams. There is, however, little being done educationally to develop the ability to conceptualize, to anticipate, to project oneself out of the bounds of one's experience.

Children should be taught to project their thoughts into situations beyond their experience or into new experiences for which new combinations of factors of knowledge or old experience must be used to synthesize a solution. The process appears to be one of anticipation, identification, and synthesis of solution.

The social studies teacher may help the child project himself into an abstract situation by asking why Columbus searched for a new trade route to the Indies; and what the Europeans needed from the Indies. After the key answer word, spices, is determined, the teacher may encourage the child to project himself into the daily life of a fifteenth century European town. If the teacher is successful, the child may arrive at the need for spices as a food preservative. In a sense, he was there.

In general science, the child may be figuratively placed in the Leaning Tower of Pisa with Galileo. It has been found from personal experience that children may return from such an adventure with formulated scientific generalizations which go beyond Galileo's efforts.

In literature courses, the teacher may help the child spend a few hours in a medieval castle experiencing drafts and inconveniences. In an effort to understand life in a medieval castle, the child will help himself to understand the meanings behind the written words of the times.

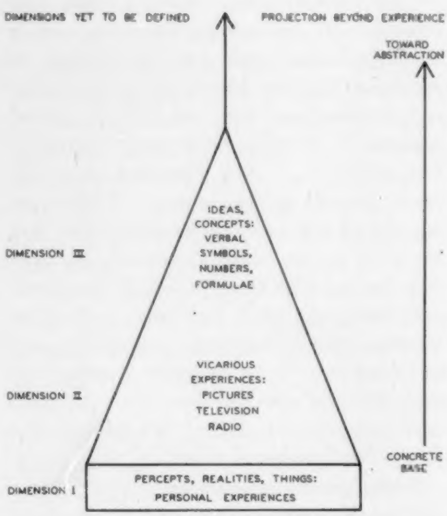
In order to gain the maximum from our most precious resource, our people, and to meet the nation's demands for an increasingly large number of competent scientists, we must add a new dimension to our list of educational objectives. Previously we have thought in terms of developing a body of knowledge, the so-called "scientific method," desirable attitudes, manipulative and tool skills, various appreciations, and applied knowledges leading to suitable behavioral changes. It would seem that we now must devise ways to teach *systems* of thinking. The scientific method is only one such system which educators try to teach, but it is limited in the outcomes it

[8] Quoted by Prof. William P. Sears, New York University lecture, June, 1954.

may achieve for children. Einstein's system, however, opens new vistas of mental activity for children.

Other systems need to be identified, analyzed, and taught. The general education course currently labeled "Ways of Thinking" customarily concerns itself with a historical study of the ways of the ancients, and with teaching variations of the so-called scientific method.

Systems of thought by which individual genius operates need to be taught. In addition to Einstein's method of projecting, other great thinker's systems need to be utilized. Our young people's minds need to be trained to go beyond experience on vehicles they create themselves or borrow and/or modify from others. The process of moving to new dimensions of abstract thought evolves in an ascending structure representing increasingly complex mental thought.



Fourth, if the United States is to be scientifically supreme, scientifically gifted persons will have to be identified early in their educational lives. We must identify and guide our exceptional minds, both those with creative and those with predictive abilities. The science teaching profession has long been aware of this need and much has been written on identifying the gifted science student and providing him with the best education possible.

Although for years the retarded were the main concern, there seems to be an increase in educational focus upon the gifted: social agency wise, the National Association for Gifted Children, teachers' colleges, and special high school classes for the gifted.

Fifth, if the United States is to be scientifically supreme, it would mean that the scientifically trained person and teacher would enjoy status at least equal to the embalmer, drugstore merchant, real estate and insurance salesman.

An examination of the editorials and editorial cartoons in the weeks following Sputnik reveals the beginnings of a new attitude toward the intellectual. It will, of course, take time to alter national attitudes to an appreciable degree, but the process has begun.

Sixth, if the United States is to be scientifically supreme, efficient use would be made of available manpower. The National Science Foundation is in the process of creating a register of scientific and technical manpower. Various suggestions for the use of central agencies for college teachers have been expounded.

There remains, however, the problem of the scientific worker whose plant closes and who must relocate. Industry has tried to alleviate the problem by placing scientific workers in other plants under the company's jurisdiction. More attention needs to be paid inter-industrywise to the problems of relocation of workers released during change-overs in one plant and employed by expanding sister industries.

Seventh, if the United States is to be scientifically supreme, science persons involved would make themselves generally available to recruitment programs. This presupposes attractive contractual offerings. Competition between industry and the government has raised salaries of those workers to a respectable level. The scientist finds himself in an enviable bargaining position and this is likely to improve, since the recent rush of activity due to the Sputniks. However, the science teacher, whose job it is to encourage the scientifically gifted pupil, and the other teachers whose job it is to help develop his attitudes and critical thinking abilities in all subject areas, have not yet reached such an enviable position as the industrial scientist.

The executive secretary of The National Science Teachers Association has written, "How long are people going to continue trying to alleviate a problem situation without coming to grips with the very core of the problem?

"The problem is how to get and keep sufficient numbers of qualified, competent science teachers. And the core of the problem is, in my opinion, salaries.

"'But,' many people say, 'salary is not the whole answer.' Other factors would include teaching facilities, teaching load, professional atmosphere, and the like, but we'll not dwell on these right now.

"We've heard dozens of proposals for 'stimulating and recognizing' good science teaching—scientists in the classroom, science teacher of the year, fellowships for summer study, and so on. Not a single one of these hits the real target—salaries. What is amazing is the amount of effort and creativeness invested in plans to improve American education without much increased spending for salaries." [9]

Eighth, if the United States is to be scientifically supreme, categories of workers need to be identified and each provided for. While the psychologists have made considerable advances in helping to identify the gifted, the nation needs people of varying degrees of skill. And these need to be identified and provision made for their education.

But here we must pause to consider grave inherent dangers in stratifying the population: threats to individual freedom, creation of national official dogma, fear of creating classes, and the questionable value of creating a scientific elite. On December 12, 1957, Dr. E. S. Burdell, President of the Cooper Union for the Advancement of Science and Art, is reported in *The New York Times* to have said, ". . . that action must assure the scientist a broad liberal arts education as well as a thorough technological education.

"The report asserted that the nation's professional schools had a specific responsibility to train scientists who could assume national leadership . . . 'Scientists and engineers having acquired the heavy responsibility of creating a new society, should also have responsibility for administering and guiding it.'"

The writer feels that the good president implied the need to *share* in the responsibility for administering and guiding a new society based upon scientific advances.

The United States needs genius, both creative and predictive; these we identify by I.Q. scales with varying degrees of accuracy. But we also need technologists: people who know why and can do, without necessarily creating or making significant predictions . . . they can lead along the road opened up by genius. Then there are the technicians: those who know how but need not necessarily know why, because they work under the direction of a technologist doing the work that needs to be done. Finally, there is the production worker who *need not* ever know what he is doing—he assembles, he does the repetitious drudgery necessary on a production line to make the idea of the genius a reality.

Although the production worker "need not know," his morale and productivity are highest when he feels a part of what he is doing. Furthermore, the individual has creative potential and his small contributions, plus those of his co-workers, may lead to larger contributions of a significant nature.

Ninth, if the United States is to be scientifically supreme, there would be a

[9] Robert H. Carleton, "Editor's Column," *The Science Teacher,* February, 1957, p. 5.

minimum waste of the potential of people involved. One hears and is familiar with stories of sabotage by individuals in x supervisory positions who, fearful of the consequences of judgment errors, refuse to make decisions—or withhold decisions until it is too late. Among the various categories of workers and administrators, we need a balance of administrative freedom for exercising responsibility without an excess of inhibiting control.

Emphasis is placed upon excess, for there are those who have delegated complete authority with responsibility. This has made a fiasco of the administrator's power to expect competency of delegated authority and provides the basis for serious morale impairment down the line of command.

It is a generally accepted human relations principle that an administrator should delegate authority commensurate with the responsibility delegated, or at least as must authority as would ordinarily facilitate the execution of the responsibility.

There are those administrators, however, who have extended the concept to include blanket endorsement of the subordinate's decisions. By the time this reasoning reaches the worker level, he may be quite confused as to the apparent support being given to an apparently wrong decision or even elementary error.

It is obvious that there is a need for support by higher authority; a subordinate would be ineffectual if not impotent without backing from above. However, there is a difference between (a) the administrative concept which provokes unqualified endorsement of subordinates' activities in the interest of promoting supposedly democratic and human relations supervision, and (b) the correct interpretation of democratic supervision based upon known principles and reality.

We read that in obscure governmental agencies, directors will face inaction rather than make wrong decisions for which they would be penalized. This is wasteful of our human resources. There is a decided need for supervision by administration of those to whom responsibility and authority are delegated. This supervision should encourage creative, independent action, without fear of reprisal. But when the subordinate is in error, exploratory sessions are in order to determine why and to provide a learning device for improvement on future performance. Obviously there comes a time when repeated failure or error may call for drastic action. This supervision needs to be a blending of traditional business supervision and manic-progressive freedom.

Tenth, if the United States is to be scientifically supreme, we need more than money, manpower, proper training, balance of administrative freedom and control. We need to assume world leadership in the ideas for man's betterment for his growth and the development of his potential, as well as in solving the technological problems. We must make a positive contribution to resolving world conflict. The United States has been struck a prestige blow. To recoup our loss, we must do more than regain scientific supremacy. We must exercise world leadership in establishing peaceful security, particularly for those nations in whose eyes we have been reduced in statute. In order for the United States to truly demonstrate scientific supremacy, we need to take the field of battle from the arena of missiles, bombs, and planes, where rounds are won intermittently, to the arena of the world's collective mind. We need to capture the imagination of the world first, and then follow through diplomatically in a supremely confident plan for world peace, man's safety, man's well being, and for an abundance of the good things for all men. Then will the United States be supreme.

We have long since the turn of the century been plagued with the statement that the social scientist has not kept pace with the physical and natural scientists; but little has been done about this.

I propose a distillation of all the world's knowledge in a way suggested by a television play. In this play, the United States had a few hours in which to avoid total destruction by a foreign power. Into a super-Univac went cards containing the knowledge of mankind. The machine was given the problem to solve: x equals peace; solve for peace.

Immediately prior to the deadline, the machine produced an answer card which had inscribed upon it the Ten Commandments. Obviously, it is too late to heed the Biblical admonitions. It is almost too late for the following suggestion.

We need to assemble the collective thought from the various disciplines—what has been learned about human behavior—what are the objectives—what recommendations can be made? It has been suggested that the world's leading minds meet at the United Nations to try to solve the problem. However, assuming invitations could be prepared which would be mutually accepted and assuming the time were available to all, and further assuming the representatives could get beyond the approving of credentials stage, is there any evidence that a face-to-face meeting of the world's leading thinkers would get beyond the glorification of motherland?

I propose a written survey to elicit a distilate of the sum total of the world's accumulated knowledge about human behavior. To each learned society would go a request for nominations for the six most outstanding scholars in each society's field. To these groups of six would go a questionnaire with these few questions:

1. What is the sum total of accumulated knowledge of human behavior in your field? Please state major principles, with isolated, related facts in subordinate order to the major principle under which each falls.
2. What recommendations can you, as an individual, make to solving the problem of achieving world peace?

A survey of this sort would cost under half a million dollars. Each of the six area specialists (and *all* the disciplines would be covered) would receive one thousand dollars in advance for his contributions. With approximately thirty disciplines, and six specialists per discipline, this would total $180,000.00. Collation of the responses would cost less than this amount, bringing the total cost to less than half a million dollars.

The nation is currently engaged in a reorganization of its thinking about the scientist and his works. The President, Congress, industry, education, and other agencies are meeting and proposing helpful suggestions to solve the problem of scientific supremacy. However, the availability of money, curriculum revision, guidance and personnel practices, national awareness and altered attitudes, and national registries will not by themselves resolve the problem of the application of our scientific supremacy to the security and well being of mankind. Nor will empty cries such as "Now is the time for leadership!," contribute to the solution of the problem.

In the eyes of a large portion of the world we have suffered a prestige blow; this technological setback need not be irretrievable. The nation is currently mobilizing to overcome an apparent technological lag. But scientific supremacy will avail us little unless it contributes to the total peace and security of the world.

It is time to take a giant step forward towards peace and work to eliminate the basis of our fears of communist conquest among the underprivileged nations. If we can establish peace and provide means to a better material world, as well as provide for its intellectual and emotional well-being, we need not worry about communism. Democracy will grow naturally, without propaganda machines to herald its desirability; for communism without a cause will die a natural death.

TECHNIQUES AND DEVICES FOR MICROPROJECTING

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INTRODUCTION

Purpose

The purpose of this article is to explore techniques and devices for microprojecting without expensive microprojectors, bioprojectors, or bioscopes. The principle instrument is the microscope used with relatively inexpensive, easy to use, readily available accessories.

Our concern will be with projecting to a screen living and non-living microorganisms and other specimens, which may also be studied by direct viewing. We are also concerned with the maximum use of the microscope, i.e., the oil immersion objective (for greatest magnification), which is ordinarily not suitable for use in projecting wet mount specimens.

Importance

Projecting has several functions when used alone or in conjunction with direct viewing. The teacher cannot be quite certain that students see what they are supposed to see. On the upper grade levels, the teacher can demonstrate by projecting. The students may then go to their individual microscopes for direct study. On the lower junior high school and elementary levels it is impractical to expect youngsters to use a microscope effectively; however, the projected image may be instructional at any level.

Frequently, there are not enough oil immersion objectives for a class; projecting extends the use of a single microscope's highest power to a whole class. Similarly, an inadequate number of microscopes makes projecting a desirable manner in which to reach an entire class.

Class discussion can be initiated by the shared viewing of a projected image. The larger picture provided by a projected image may be somewhat more motivating than the individual (often frustrating) direct view through the microscope.

Time saved by projecting is an important factor for classes in which students have to wait in line to take turns at a demonstration microscope. With the acute teacher shortage and larger class size, the teacher can better supervise microscope work by projecting demonstrations prior to individual work.

Closed circuit television is growing. However, the television teacher's microscope is next to useless unless the view can be shared with distant classes. One way to solve this problem is to project to a screen, which the television camera can reproduce on the viewer's television screen.

Since this article was first outlined, over a year ago, two professional articles on projecting have come to the writer's attention,[1] indicating the importance of this work.

Problems

The process of projecting is relatively simple. However, there does not appear to be a comprehensive report of the various aspects of the techniques of projecting, some of which are problems. For example: what kind of screen should be used; how are motile forms made to move slowly; how are living organisms stained; what method of lighting can be used; how is the image reflected from the body tube of the microscope to the screen; how can heat be reduced to prolong the life of the specimen; how is the oil immersion objective used with wet mounts. Each of these problems are discussed separately.

[1] Ruth Frank, "Microprojection Method," *The Science Teacher*, Vol. XXV, No. 7 (November, 1958), p. 402. S. Alton Yarian, "More Front Seats," *Star '58*, National Science Teachers Association, pp. 10–12.

TECHNIQUES

The Screen

The usual beaded screen is not completely satisfactory. The image of microorganisms is distorted and often lost among the valleys between the beads. In his Science Teacher Achievement Recognition Award article, Yarian[2] recommends a translucent vinyl sheet.

In order to gain the space lost by the projecting table and instructor, it is recommended that the table and teacher be placed *behind* the vinyl sheet and the image projected *through* the sheet. The effective projecting distance is six to twelve feet and frequently students on the sides and in the back are out of range of the view. The space thus saved may be used for better viewing by a larger number of students.

Another effective screen is made of white smooth construction paper tacked to a composition board or taped to the blackboard.

Anesthetic for Protozoans

Bovee[3] reports in *Turtox News* that protozoa are hard to follow at higher magnification. Bovee quotes Thomas[4] on the use of nickel sulfate (Ni SO_4) to slow down rapidly moving organisms. ". . . a solution of 0.4 gm. of Ni SO_4 dissolved in 1,000 mls. of distilled water, or filtered pond or culture water. A drop of the Ni SO_4 solution is mixed with an equal amount of culture. . . . The organisms are thus in a Ni SO_4 solution of 0.02 of 1 per cent."

Staining

Ordinary laboratory stains kill microorganisms. While many vital stains are excellent for preserved materials, the problem of staining living microorganisms is incompletely solved. The use of India ink has been reported as satisfactory with paramecia.

Yarian[5] reports the use of polarized light is satisfactory with *macroorganisms.* This writer has not found polarized light successful with *microorganisms,* but admittedly his experience and competence is limited. Further work is needed in this area by other investigators.

It is hoped that in the future, a report will be forthcoming on the uses of vegetable dyes, and radioactive and luminescent meals. These materials and others may provide solutions to this problem.

Lighting

The greater the concentration of light, the greater the projecting distance. It has been found that a 750 watt unconverted slide projector does not provide as much light, for projecting through a microscope, as a converted microscope lamp of only 250 watts.

Frank reports[6] success using "an unmodified slide projector." This writer has found that the slide projector is successful, but limited in the distance it will project an image through a microscope: six to eight feet with low power, less with high power and oil immersion.

One of the best light sources this writer has found is a microscope lamp equipped with a double convex lens adapter. The adapter converges parallel rays to a point.

Probably the best light source is a carbon arc lamp. Richardson and Cahoon[7] give

[2] *Ibid.,* p. 10.

[3] Eugene Bovee, "Nickel Sulfate as an Anesthetic for Protozoans," *Turtox News,* General Biological Supply House, Chicago, Illinois (unknown issue in 1958).

[4] Raymond Thomas, "L'Action Anesthetique du Sulfate de Nickel sur Paramecium candatum," *Bulletin de Microscopie Appliquee,* Vol. 3, 1953, pp. 73–76.

[5] S. Alton Yarian, "More Front Seats," *Star '58,* N.S.T.A., p. 11.

[6] Ruth Frank, "Microprojection Method," *The Science Teacher,* Vol. XXV, No. 7 (November, 1958), p. 402.

[7] John Richardson and G. P. Cahoon, *Methods and Materials for Teaching General and Physical Science.* McGraw-Hill, New York: 1951, pp. 133–4.

directions for making an inexpensive carbon arc lamp. There are problems of cooling the light provided by the carbon arc and other light sources; these are discussed in the section on *Cooling*.

Reflecting

There are two basic positions of the microscope in microprojecting: one, the microscope is in its usual vertical position; two, the arm is bent so that the body tube is in a horizontal position.

In the vertical position, the light source is focused on the substage mirror, which in turn reflects the light up through the body tube. A low ceiling may provide a suitable screen, but this has obvious disadvantages. An alternative is to reflect the light at the ocular horizontally to the screen.

Reflecting from the vertical position of the microscope is accomplished by introducing a prism attachment at the ocular. However, these attachments are costly and provide an additional step at which precious light is lost. A less expensive method is to use a lady's pocketbook mirror, ring stand, and clamp to direct the light to the screen. However, this system also provides for loss of light by the mirror.

In this writer's opinion, the best method is to put the microscope in its horizontal position, remove the substage mirror, and project directly through the body tube to the screen. However, this system has not been practical with wet mounts of living organisms, until recently; this will be discussed further in the section on *Devices*.

Cooling

Powerful light sources, used by commercial projectors and the system described in preceding sections, create problems. Wet mounts dry quickly; the liquid medium is lost rapidly by evaporation. As the liquid medium evaporates, there is a flowing of the preparation to the center which causes microorganisms to move rapidly past any given field. If a cover slip is used, bubbles are formed as the medium evaporates. Bubbles prohibit the examination of the sections of the slide where they are formed.

Present methods of cooling are relatively successful. "Aklo" and other heat absorbing lenses may be used. "Aklo" will absorb up to 80 per cent of the heat with a 10 per cent light loss.

A blue glass substage filter reduces the infra-red end of the spectrum, but considerably reduces the light.

Copper sulfate solution, one-half per cent, in a flat sided container is frequently mentioned in the literature, and is useful within its light-loss limitations.

For use with low and high dry powers, a partially filled Petri dish placed directly on the stage in the vertical position has been found helpful. However, the Petri dish cannot be tilted and there is a double light source loss: the extra attachments for projecting in the vertical position (substage mirror and prism), and the glass of the dish plus the depth of the extra liquid medium.

An untried system which perhaps should be developed would reduce the light without any loss of *usable* light and consequently considerably reduce the heat. The system would be based on an attachable movie shutter for the light source. The shutter would block out the light intermittently as in a movie projector and rely on persistence of vision to maintain a continuous view of the specimen.

Using the Oil Immersion Objective

The oil immersion objective is used with wet mounts in two principle ways, both unsatisfactory. One, a cover glass is ringed with vaseline and applied to a glass slide holding the liquid medium. Two, a cover glass is ringed with vaseline, the specimen is added to the surface of the cover glass which has the vaseline, and the cover slip is applied to a "hanging drop" concavity slide.

If the microscope is tilted with either of the above slide preparations, the specimen will run into the vaseline. If oil immersion is used, the cover glass will move from side to side when fine adjustment is made. With both coarse and fine adjustment, the cover glass will rise with the oil of immersion.

The writer has tried unsuccessfully to use concavity slides which were full of liquid medium in the hope that adhesion would keep the cover glass in place. It is true that the preparation could be tilted, but focus of the oil immersion objective was impossible to obtain even in the vertical microscope position.

To overcome the problems of tilting and using the oil immersion, the following slides were created and are discussed in the section on *Devices*.

DEVICES

A patent search and examination of supply catalogues reveal that there are no existing devices to overcome the problems with wet mounts of tilting, using the oil immersion objective, and avoiding: evaporation, flowing of organisms, and bubbles.

A series of slides was developed which overcame the above problems; the major model is called a "microbiological projecting and viewing chamber."

While we have been discussing microprojecting techniques, we are also concerned with the individual student who must sit uncomfortably at a microscope in the vertical position when he studies a wet mount. The following devices may be used by the individual viewer with the microscope tilted for convenient viewing or for projecting with the microscope in the horizontal position.

Model I

This slide is constructed of three pieces of Tenite, an acetate which is easily cut, drilled and bonded. However, a wide variety of plastics and other materials may be used. The base is ¼ inch thick and one by three inches in length and width.

A chamber section is bonded to the base with acetone. The chamber piece is 20/1000 of an inch thick and one by three inches in length and width, with a half inch hole bored in the center.

When the above pieces are firmly set, a 1/16 inch diameter hole is bored from the inside edge of the chamber to the long edge of the base; this angled hole should extend to the center of the ¼ inch thickness. A 3/16 inch countersink is made from the ¼ inch edge, approximately ¼ inch into the existing hole.

Finally, the top is bonded to the chamber, using 4/1000 of an inch thick acetate which is the thickness of a cover glass and within the working distance of the oil immersion objective. The piece is one by three inches in length and width.

A small rubber stopper is trimmed on two sides and inserted into the 3/16 inch countersunk hole. The stopper can be taken from a small vial of feline distemper vaccine, which any veterinarian will be able to supply.

The stopper is not essential as liquid introduced into the chamber will not run out, even without the stopper.

To use this model, fill the chamber by withdrawing air with a hypodermic syringe and needle. Next introduce the specimen into the partial vacuum. There will be no leaking, bubbles, drying, or flowing of organisms; the slide may be tilted in any direction; and the oil immersion objective may be used with success.

The chamber is cleaned by flushing with fresh water, using the syringe after the stopper has been removed.

This model may be made with two or three or more chambers for use with several specimens. The student or teacher will be saved several trips to the stock cultures and have fewer slides at his work area. In addition, the study of features of different species of an organism or between different classes of organisms can be readily made without changing slides, either in individual work or in projecting.

Yeast or non-motile bacteria may be introduced into the chamber to study Brownian movement.

Model II

This model is essentially the same as Model I, but it is constructed to permit the study of galvanotropism: the response of living things to electricity. The only difference between Model I and II is that Model II has two 1/16 holes, one each bored from the inside edge of the chamber to the short ends of the base. Wires are introduced through the holes to the edges of the chamber. Two inches of wire may be left protruding from the edges of the slide. The wires are sealed in place with acetone.

The wires are attached to a weak battery after a heavy culture of paramecia is placed in the chamber. The organisms will move to the negative pole. Switch polarity at the battery and the organisms will be seen to move to the opposite side of the chamber.

Model III

This model has the same use and advantages as the first two models but it is intended to be a one-time-use slide, that is, it is a disposable model.

The base and chamber are the same as in the other models. In Model III, a shoulder piece is bonded to the chamber. The shoulder piece is 4/1000 of an inch thick. A section is removed from this piece to form a shoulder. The section removed will be as wide as a cover glass and 1/16 of an inch shorter. The section will be removed from the center of the shoulder piece along the long edge. The shoulder piece will then be U shaped with thick legs. When this piece is in place, a cover glass inserted into the shoulder will be centered over the chamber.

The top piece is 20/1000 of an inch-thick-Tenite with a 5/8 inch hole bored in the center. This piece is bonded to the shoulder.

To use this model, fill the chamber and collar with the specimen to be studied. Insert a cover glass into the edge of the slide where there is an opening left by the shoulder. The cover glass will move in the track provided by the shoulder. A sealed effect is achieved which overcomes the same problems as the other models. Excess material is wiped off and the specimen may be studied with low or high dry power or the oil immersion objective.

Model IV

This model is the same as Model III, except that as in Model II it has the wires for demonstrating galvanotropism. The manner of making the holes and demonstrating the process is the same as described in Model II.

A secondary use of the four models is for mailing purposes. The slides may be filled with specimens to be studied at hospitals, research centers, technical institutes, State and Federal Departments of Agriculture, or sharing with distant colleagues, and mailed.

Model V

While this model is not strictly within the frame of reference of the topic, it is an obvious outgrowth of the previous models. In order to demonstrate both galvanotropism and/or chemotropism, the following slide may be used.

The same base as before has bonded to it a chamber cut into a piece of 40/1000 inch thick Tenite (or two pieces of the 20/1000 stock). The chamber is centered to run the length of the piece and is approximately ¼ of an inch wide by 2¼ inches long. After the chamber is firmly bonded to the base, two holes 1/16 inch in diameter are drilled from the inside edges of the chamber to the outside edges of the short ends of the base.

The holes are then enlarged to 5/64 of an inch in diameter. Next, three-quarter-inch screws with a 3/32 diameter are placed in the holes from the end of the slide so that the points just enter the chamber. The heads of the screws will protrude at the ends of the slide and wires from the batteries may be wound around them. The screws are sealed in place with acetone.

CONCLUSION

It is hoped that these slides will be useful to colleagues. It may be that these slides will soon be available commercially to save teachers the effort of making them.

Regarding the incompletely solved problems of staining and coloring with polarized light, it is hoped that other researchers will contribute to the presently inadequate knowledge of the subject.

EXPERIENCES IN A SUMMER SCIENCE INSTITUTE

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THE primary reason for writing this article is to encourage others to attend the various institutes conducted and sponsored by the National Science Foundation which are available throughout the United States to all science teachers. I feel that if I relate some of the experiences I encountered last summer and list the many benefits received, others will be prompted to take advantage of these educational opportunities.

I had often dreamed of visiting California but never had the financial resources to make it a reality. I had rather half-heartedly filled out three application blanks for the N.S.F. Scholarships last summer. I was wishfully hoping, but not really confident of obtaining either of the three. My reason for relating this incident is because I know many persons feel the same as I did, "Oh, what's the use!"

My arrival at the California airport was climaxed with anxiety. As I stepped from the plane I was greeted with a familiar environment; the lush greenery, the warm sunshine and the casual sports attire predominantly found in tropical surroundings of Florida. The similarity was so striking, I felt very much at home.

We were advised to bring cameras, sleeping bags, camping clothing, and dissecting sets. Along with these, I added a pocket magnifying glass, movie camera, radio-clock, blanket and four biology reference books, the latter being checked out of the professional library for the summer. I felt secure and welcomed the challenges of the summer session.

The institute was held at the University of California in Los Angeles which is one of the eight campuses included in the world's largest university. The group included 18 stipend-holders, four of which were women. There were only five of us who were not connected with the California school system. One of the five was a Filipino, one was Chinese, two were southerners and one was a westerner. This class constituted the Life Science Institute. We actually lived life science during the entire six-week period and enjoyed every single minute of it.

At the opening session our professor introduced each member of the group. He very quickly went over the class tentative agenda for the summer and then we were oriented to the campus with a tour. We spent approximately forty-five minutes in the medical library being briefed by the head librarian on procedures, classification system, and the general outlay of the library.

The very first week found us camping out in sleeping bags for two days in the Mojave Desert. We trapped animals, studied the ecology of our surroundings, built nightly camp fires for brewing coffee, exchanged experiences and really got to know one another.

We were to have a barrage of field trips, beginning the next day, for overnight, weekends, and during the day. They were to include trips to the desert, the zoo, the mountains, the seashore and tramping through the woods. I have listed below many of the trips we made.

1. Los Angeles County Museum.
2. The La Brea Tar Pits.

3. Numerous trips to many and varied seashores. Corona-del-Mar and Malibu Beach were used extensively because they were rich resources for marine organisms during high tide. I was able to bring back a personal collection of over 40 marine invertebrate organisms. This has started me on a fascinating hobby I hope to continue.

4. The San Diego Zoo. The San Diego Zoo is second only to London Zoo in completeness. The London Zoo has more variety than any other in the world. We spent two days living at the San Diego Hotel while exploring the zoo. This time was well planned behind the scenes, one-half day was dedicated to the Primates, the other half included the other areas.

4. Scripps Oceanarium, another of the University of California's campuses, is located directly on the Pacific Ocean and students take dips in the surf between classes. Here we studied organisms within their natural habitat.

6. Our class stayed up in the hills appreciating the beauty and splendor of the Montane Forest, identifying the many kinds of pines, brush, and scrubs characteristic of that region.

7. Yellowstone Park and Yosemite were visited by individual groups of students who wanted to make the trip.

8. The Grungion Run. This field trip stands out above all others to me and I shall always remember it. We arose at 2:00 A.M. while it was still dark and cold, slipped out of the sorority dormitory, each carrying his own flash light, piled into cars headed for the beach. This was the time for the high tide which would bring in the little grungion fish, leaving them on shore long enough to mate, lay and bury their eggs in the sand and return to the sea. All of this took place in a very short period of time; therefore, timing was very important. Incidentally, the grungion are the only fish in the sea who mate on land.

9. Small groups of students made visits to Marineland, Knox Derry Farm, and the Planetarium.

Formal classes were held in the mornings from 10:00 A.M. to 12:00 noon, leaving our afternoons free for laboratory work. Below, I have mentioned a few of the highlights from these class sessions.

1. The importance of reading and knowing the classics of science. Such classics as: Darwin's "Origin of Species," Mendel's "Papers on Genetics," and Linneas' "Systema Naturae."

2. We were urged to substitute another example for the study of Phylum Annelida in place of the earthworm. The reason for this was because of the characteristics listed below which are considered typical of Annelida and are not found in the earthworm.

a. No developed exoskeleton.

b. No developed sense organs.

3. An introduction of a new and separate kingdom aside from plants and animals. Protist (microscopic forms).

4. We were encouraged in the wider use of plants in the laboratory for the following reasons:

a. They are easier to maintain.

b. They are easier to obtain.

c. Little or no criticism from outsiders when they are used for experiments.

Example: Plants may be cut or destroyed in the laboratory and no one complains.

5. What is reproductive potential of an organism? A discussion of the factors holding down the reproductive potential in this struggle for existence.

a. Crowding.

b. Competition.

6. Teachers should give the concept of the universe as being finite, boundaryless and expanding.

7. We were introduced to a new system of classification of plants which differed greatly from the other in that it separated the algae. One reason the old system was discarded was because it failed to show the true evolutionary picture and relationships.

Example:

CYANOPHYTA	— Euglena
EUGLENOPHYTA	— Blue-green algae
CHLOMAPHYTA	— Green algae
PHAEOPHYTA	— Brown algae
RHODOPHYTA	— Red algae

8. Scientists are returning to the concept of "Spontaneous Generation," the theory introduced by Aristotle, as the explanation of the origin of life. Could it possibly be taking place today?

9. Life began with the Autotrophs (self-feeding green plants) and Heterotrophs (other feeding) followed.

10. How should virus be classified? Are they living or dead? Virus may be crystallized out and kept on the shelf for years, exhibiting no form or signs of life. Perhaps the answer lies in our redefining what life is.

Below I have listed some of the interesting experiments performed in the laboratory during the institute.

1. Protozoology Laboratory—The purpose was to acquaint us with the use and handling of protozoa as a laboratory animal.

2. Fertilization was demonstrated with paramecium, tetrahymena, and chlamydomanas.

3. Genetic Laboratory—The two organisms used were corn and Drosophila.

4. Mammal and Reptile Laboratory—This session was concerned with the identification and preservation of materials collected on the Mojave field trip.

5. A Caesarean delivery of a fetal guinea pig.

6. Embryology Laboratory—A study of fertilized eggs at various stages.

7. Plant Hormone Laboratory—The use of growth substances to produce cell elongation.

Each of us carried on our own bit of scientific research or completed a project. The activities selected were as varied as the individuals. At the culmination of the course all projects and researches were displayed and discussed individually.

If I gave the impression that I was loaded with equipment when I left, imagine what it was like on my return. I had 40 Marine specimens collected, bottles of Gibberellic acid and 150 embryology slides, 65 visual aid slides, 3 bottles of fruit flies and 2 rolls of movie films plus many pamphlets, books, and pictures I had acquired to help me in the teaching of science.

For this, I had to give thanks to The National Science Foundation for a wonderful, informative and fascinating summer science session.

AN EVALUATION OF THE 1958 SUMMER INSTITUTES ATTENDED BY SCIENCE AND MATHEMATICS TEACHERS FROM THE NEW YORK CITY HIGH SCHOOLS

SAMUEL SCHENBERG
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Board of Education of the City of New York, Brooklyn, New York

INTRODUCTION

SUMMER institutes have, within a short period of five years, added a new dimension to teacher training in American education. These institutes are organized across the country to enable science and mathematics teachers to strengthen their backgrounds in their major and related fields of study and to keep abreast of modern developments which occur in explosive profusion.

In the past, only a relatively small percentage of high school teachers of science took graduate courses in specific science areas to fulfill a desire to keep up-to-date in their college major. By and large, most high school teachers took a master's degree in science education which provided the professional "know-how" and helped them to advance in the teaching profession. As time passed, these highly experienced teachers suddenly found themselves hopelessly behind the constant flow of new ideas and developments. They found that the science taught in the classroom no longer related to the science reported in the newspapers, in the magazines, over the radio and on the television screen. Many of their students lost interest in a science which did not explain what was going on from day to day. The "know-how" could not operate effectively when the "know-what" was lacking.

Since world tensions made it imperative to interest and prepare many of our talented youngsters to specialize in science, a number of leaders in science and in science education, with the cooperation of far-sighted industrial and educational foundations, entered the science and mathematics institute field. They operated on the assumption that the most fruitful areas for direct and immediate attention were the high schools of our country within whose walls talented youngsters were interested in scientific careers. They became convinced that the high school teachers of science and mathematics were the key to the solution of the manpower problem. With the entrance of the National Science Foundation upon the scene, the institute training program went into high gear on a scale never before envisioned in American education. The NSF makes grants to colleges for the purpose of designing and organizing institutes along subject matter lines. These institutes are planned to bring teachers of science and mathematics up-to-date in the areas they are teaching and to assist these teachers to utilize the new ideas in their classrooms for the benefit of their students. In order to compensate teachers for possible loss of summer employment, they receive an honorarium of $75 per week, $15 per week per dependent (limited to 4), traveling expenses and free tuition.

It seemed desirable to evaluate the summer institutes in order to determine the extent to which they were attracting New York City teachers and, at the same time, to measure their impact upon the science and mathematics teaching in New York City. The study was initiated by means of a questionnaire which was distributed by the principals in 56 academic, 30 vocational and 127 junior high schools to the science and mathematics teachers in their schools who participated in a 1958 Summer Institute Program. (A copy of the questionnaire is set forth in the appendix.)

SUMMARY

1. During the 1958 summer vacation, 110 secondary school science and mathematics teachers, 79 from academic, 20 from vocational and 11 from junior high schools, attended 30 Summer Institutes located in 17 states in an arc from Maine to California. The group contained 16 women and 94 men.

2. The National Science Foundation sponsored 25 of the Summer Institutes, the Esso and Shell Oil Education Foundations sponsored one a piece, and the New York State Education Department sponsored three.

3. Eighty-nine or 81 per cent of the 110 New York City teachers attended institutes outside of the metropolitan New York City area and 76 or 69 per cent of them were accompanied by their wives and children.

4. The time spent in daily attendance varied widely from 2 to 8 hours daily. The largest number of teachers attended classes 4 hours daily and followed them with 2 hours of homework.

5. The teachers found the summer institutes extremely valuable, interesting and stimulating. The institutes brought them up-to-date with the latest advances in the fields they were teaching as well as with fields in related sciences and mathematics. They learned many new techniques which they were able to put into immediate use in their classrooms. They felt that the training they had received enabled them to motivate their students better than they had been able to do in the past.

6. The teachers directed attention to a number of shortcomings in the planning and operation of the institutes. They found that the institutes covered too much ground, required too much homework, neglected adequate articulation with the high school science and mathematics courses, failed to enroll homogeneous groups, and failed to provide adequate time for the exchange of ideas among the teachers.

7. Many suggestions for the improvement of the summer institutes were made. These suggestions called for brochures containing better descriptions of the scope and content of summer institutes to enable the teachers to make a wiser choice, a central agency to process applications in order to decrease duplications and the necessity for filing multiple applications, high school educators alongside of college educators in the planning and conduct of the institutes in order to secure better articulation, starting dates on or after July 1st to enable all teachers to apply, summer institutes to run over 2 or 3 summers in order to provide the time necessary for intensive training in a given area, symposia on the stimulation of talented youth in science, a bibliography to selected participants to enable them to prepare for the opening sessions, field trips to places of scientific interest, and better accommodations for families.

FINDINGS

General

An undetermined number of science and mathematics teachers applied for admission to the 1958 summer institutes. One hundred and ten teachers were selected. They were composed of 94 men and 16 women. They represented a cross-section of the science and mathematics teachers who served from less than one year to 35 years in the secondary schools in New York City. See Table I.

TABLE I

CLASSROOM EXPERIENCE IN THE NEW YORK CITY SECONDARY SCHOOLS

Category	Years of Service	Number of Teachers
1	0–1 (substitutes)	9
2	2–5	23
3	6–10	11
4	11–15	17
5	16–20	11
6	21–25	24
7	26–30	14
8	31–35	1
	Total	110

The foregoing data indicate that 32 or 30 per cent of the teachers were in categories 1 and 2 and were therefore less in need of refresher courses than were teachers in categories 3 to 8. The need of refresher courses increases as the number of years since graduation from college increases. Teachers in categories 3 to 8 require such training the most. Contrary to a popular misconception, the above data prove that there is no discrimination practiced against the older teachers in the summer institutes.

The 110 participants from New York City are presently teaching in 65 secondary schools, 79 of them in 40 academic high schools, 20 in 15 vocational high schools

TABLE II

LICENSES POSSESSED BY PARTICIPANTS FROM NEW YORK CITY

License	Number of Participants	
1. Chairman of biological sciences	7	
2. Chairman of physical sciences	7	
3. Chairman of related technical subjects	5	
4. Chairman of mathematics	2	
5. JHS principal (formerly teacher of physics)	1	
6. Asst. principal (formerly teacher of chemistry)	1	
7. Biology	11	
8. Chemistry	18	(includes 2 substitute teachers)
9. Physics	11	
10. Earth science	1	
11. General science	10	
12. Mathematics	32	(includes 7 substitute teachers)
13. Applied science	1	
14. Semi-technical physics	1	
15. Laboratory assistant	2	
Total	110	

TABLE III

LOCATION AND TYPES OF INSTITUTES

State	College	Sponsor	No. of N.Y.C. Participants	Subject Content *
1. California	University of California	NSF	2	RB, P
2. Connecticut	University of Connecticut	NSF	4	P(MIT)
3. Connecticut	Wesleyan	NSF	11	B, C, P, M, ES
4. D.C., Washington	American University	NSF	2	C, P
5. Kansas	University of Kansas	NSF	1	M
6. Maine	Bowdoin	NSF	2	P(MIT)
7. Maryland	Morgan State	NSF	1	C, P, ES
8. Massachusetts	Harvard	NSF	1	RB
9. Massachusetts	Tufts	NSF	7	C, P, M
10. Michigan	Michigan State	NSF	1	M
11. Montana	Montana State	NSF	7	C
12. New Hampshire	University of New Hampshire	NSF	1	C, P
13. New Jersey	Stevens	NSF	2	C, P
14. New York	Adelphi	NSF	8	RB, C, M
15. New York	University of Buffalo	NSF	6	M
16. New York	Clarkson Inst. of Tech.	NSF	4	C, P, M
17. New York	Cornell	Shell	2	P, M
18. New York	Fordham	NYS	5	P, M
19. New York	Hunter	NYS	6	M
20. New York	Oswego State Teachers	NYS	1	P
21. New York	Rensselaer Poly. Inst.	NSF	7	C, P, M, ES
22. New York	Sarah Lawrence	NSF	1	GS, SS
23. New York	Union	NSF	6	B, C, P, M
24. Ohio	University of Ohio	NSF	4	C, P, M
25. Pennsylvania	Allegheny	NSF	2	B, P, ES
26. Pennsylvania	Lafayette	NSF	1	C, P
27. Pennsylvania	University of Pennsylvania	Esso	2	C, P
28. Rhode Island	Brown	NSF	4	B, C, M, ES
29. Tennessee	Oak Ridge	NSF	4	RP, P(MIT)
30. Wisconsin	Ripon College	NSF	4	C, P, M

* B—Biology, C—Chemistry, ES—Earth science, GS—General Science, M—Mathematics, P—Physics, P(MIT)—MIT high school physics, RB—Radiation biology, RP—Radiation physics, SS—Social Studies.

and 11 in 10 junior high schools. New York City has 56 academic, 30 vocational, and 127 junior high schools. The teacher-participants possessed 15 different licenses. See Table II.

The above data reveal that 23 or 20 per cent of the successful candidates possessed supervisory and administrative licenses. The largest single group of teachers, 32 or 29 per cent of the participants, were licensed in mathematics. The next largest group, 18 or 16 per cent, possessed chemistry licenses. Laboratory assistants do no formal teaching. The two, who were accepted, found that they had learned many new techniques which would be of great value to the teachers in their departments.

Questions 1, 3, 7

1. Name the college and location of the institute.
3. Name courses studied.
7. Was the institute sponsored by NSF? If not, name sponsor.

The teachers attended 30 institutes offered by 30 colleges in 17 states across the country. Ten of the institutes were situated in New York State and 2 of them were in New York City. See Table III.

Nine or 30 per cent of the institutes offered only one field of science or mathematics for study, ten or 33.3 per cent offered two areas, six or 20 per cent offered 3 areas, four or 13.3 per cent offered 4 areas and one or 3.3 per cent of the institutes offered 5 areas. Teacher-participants were able to pursue the study of biology in 4 institutes, chemistry in 16, physics in 19, mathematics in 13, radiation biology in 3, radiation physics in 1, MIT high school physics course in 3, earth science in 5, and general science and social studies in 1. In many institutes teachers were required to take courses in 2 or 3 areas during the summer.

Questions 2, 4, 5, 6

2. State dates and duration in weeks.
4. How many hours were spent in attendence per day?
5. How many hours were spent in preparation per day?
6. Were you accompanied by your spouse? How many other dependents?

The 30 summer institutes ranged in length from 2 to 8 weeks. Most of the institutes, 25 or 83 per cent, were 6 to 8 weeks long. See Table IV.

TABLE IV

DURATION OF SUMMER INSTITUTES

Number of Weeks	Number of Institutes
2	1
3	1
4	1
5	2
6	17
7	1
8	7
Total	30

The two-week course was sponsored by the New York State Education Department at the Oswego State Teachers College and was devoted to a study of electronics. The three-week course was sponsored by the NSF at Sarah Lawrence College and was devoted to a workshop on Science and the Social Studies for both science and social studies teachers. The four-week institute was sponsored by NSF at Oak Ridge and was devoted to nuclear physics and radioactive isotopes.

The institutes were scheduled from 2 to 8 hours daily and the teachers claimed that they spent from one to 8 hours in daily preparation. See Table V.

TABLE V

HOURS REQUIRED DAILY FOR ATTENDANCE AND PREPARATION

Hours Required Daily	Number of Teachers Attendance	Number of Teachers Preparation
1	0	9
2	3	37
3	17	24
4	26	14
5	20	13
6	19	7
7	12	2
8	13	4
Total	110	110

These figures indicate that 20 or 18 per cent of the teachers spent 3 or fewer hours in daily attendance, 65 or 59 per cent spent from 4 to 6 hours in daily attendance and 25 or 23 per cent spent from 7 to 8 hours in daily attendance. The figures also show that 46 or 42 per cent spent only 1 to 2 hours in preparation, 38 or 35 per cent spent from 3 to 4 hours, 20 or 18 per cent spent between 5 to 6 hours, and 6 or 5 per cent spent 7 to 8 hours in daily preparation for their courses. The above data clearly indicate that most of the teachers found very little time for relaxation.

In the group of 110 teachers, 63 or 57 per cent were accompanied by their wives and 55 or 50 per cent of them brought their children. Twelve of the teachers were accompanied by one child, 35 by two children, 7 by three children, and one teacher brought 4 children to the institute.

Questions 12, 13

12. Are you planning to attend an institute next summer? Where? What type?
13. How many prior institutes have you attended in the last 5 years? (If you have attended prior institutes please list them on the reverse side and give the location and dates of each. Comments on each of these institutes will be welcomed.)

These questions were asked in order to determine whether the same or different teachers were attending institutes each year.

Eighty or 73 per cent of the participants had never attended an institute previously, 26 or 24 per cent attended one previous institute, 3 or 2 per cent attended 2 previous institutes, and one of the teachers attended 3 previous institutes. These data indicate that approximately one in every four teachers had previously attended an institute. Three out of 4 of the teachers attended their first institute during the summer of 1958.

Sixty-four or 58 per cent of the teachers decided that they would apply for admission to a summer institute in 1959, 29 or 26 per cent were undecided and 17 or 16 per cent would not apply for admission to a summer institute in 1959.

Question 8

8. What were some of the "high points" of the institute?

The summer institutes gave the teachers the opportunity to go back to school for needed instruction in the latest advances in their own subject fields. They found this a most stimulating experience. They enjoyed personal contacts with the faculty members and guest lecturers who were uniformly of high caliber and very helpful and friendly. They acquired new techniques and became acquainted with the application and use of new procedures and equipment. Many found the trips planned by some institutes, very exciting. Some of the teachers visited the Argonne Laboratories, Bell Telephone Laboratories, oil refineries, Brookhaven National Laboratory, an aluminum plant, fields exhibiting geologic formations and fossils, a copper mine and smelter and the Yerkes Observatory. Teachers in the radiation biology institutes were pleased with the scaler presented by the AEC. One group enjoyed working in the National Bureau of Standards Laboratory. All of the teachers welcomed the opportunities for discussions and exchange of ideas with teachers from other parts of the country. They appreciated the provisions made for their families, and for planned social activities. They were pleased with the graduate credit they received. They came back to their classrooms and students surer of themselves than they had been for many years.

One teacher, with 23 years of teaching experience, summed up the views of most teachers by writing, "In terms of vital experiences, instruction gathered and uplifting of morale, the institute was the most potent influence in my teaching career."

Questions 9, 10

9. In what ways could the institute have been improved?
10. What suggestions can you make for the improvement of future institutes?

The teachers pointed out a number of imperfections in the conduct of the institutes and offered suggestions for their elimination as well as for the improvement of future institutes.

Most of the teachers complained that too much work was crowded into each session.

They felt that less work would have enabled them to secure a better understanding of the topics in the course of their presentation and development. Many advocated that all institutes be a minimum of 8 weeks in duration. Others felt that institute programs should be developed to span two or three summers and thus enable the teacher-participants to gain a high degree of mastery in the subject field.

Most of the teachers were of the opinion that a great deal of the subject matter was never related to the needs and activities of high school teachers and therefore was only partially effective. They advocated better articulation between the high school teachers and the college professors. If the chief goal of an institute is to make better high school teachers, the inservice institute must provide opportunities for correlating and articulating the subject matter of the professor's lecture with the work of the teachers in their own classrooms. These opportunities should include more laboratory and project work.

Many teachers felt that some institutes were not as effective as they could have been because no attempt had been made to select a homogeneous group of teachers. The backgrounds of the teachers sometimes varied to such an extent that some found the pace too fast and others found it too slow. Different institutes should be geared to levels of competence as determined by college subject backgrounds of teachers.

New York City teachers suggested that all summer institutes start on or after July 1. This would enable them to apply for admission to institutes all over the country. The cross fertilization of ideas from teachers from different parts of the country proved very stimulating to the teachers.

Many of the teachers advocated the formation of a central bureau to process all applications. This method would eliminate the necessity for securing and filing many applications and would serve to avoid some being accepted two years in succession while others were unable to participate at all.

Many felt the need for some prior preparation preceding the opening sessions of the institutes. They advocated brochures containing better descriptions of courses, followed by a list of topics and a suggested bibliography for all selected candidates. These procedures would enable successful candidates to make some preparation prior to the opening of the summer institutes.

Teachers agreed that more time should be allowed for informal discussions with instructors and with one another. These discussions should take place during and after lectures and also in symposia arranged for one or two nights a week. Some were dubious of the teacher-student relationship which existed in some of the classes and suggested the need for a more professional atmosphere in these classes.

Many teachers felt that institutes should specialize in one field only. Requiring courses in two or more fields proved taxing to teachers and diluted their efforts and understanding.

A number of teachers suggested that the library be kept open evenings and on weekends to permit more individual reading and research.

Some recommended model lessons to show how the new subject matter could be presented to high school students. Material presented should not only be up-to-date but should enrich the subject matter the teachers will be called upon to present to their students. The teachers voiced the need to learn how to stimulate their talented students.

One teacher suggested that the NSF should provide fellowships which could be used to take regular summer courses in any college in addition to those offered in summer institutes.

A number felt that the directors paid no attention to the fact that the teachers were on vacation and needed some relaxation. In many instances, no attempt was made to organize suitable social activities for the teachers and their families. Some did not provide convenient accommodations for families. Teachers recommended the use of one dormitory for all participants in an institute in order to promote more informal contacts during the summer session.

Question 11

11. How can the training you received be used to benefit (a) other teachers and (b) talented students?

Question 11 sought to determine ways and means of disseminating the new knowledge and enthusiasm, received by the teacher-participants, among other teachers in their schools and among their own and other students. That the Summer Inservice Institutes were making an impressive impact upon teachers, schools and school systems can be seen by the following contributions from the teachers. They made lecture notes and mimeographed material available to other teachers in their schools. They delivered talks at department meetings and at local meetings of teachers' professional societies. Some acted as consultants on methods for presenting new topics to other teachers. Many prepared appropriate bibliographies. Others constructed pieces of equipment useful for all teachers in their departments. Some volunteered for, and were giving, advanced courses. They suggested changes in present syllabi and the purchase of new equipment. A few wrote articles for scientific journals. They stimulated other teachers to attend summer institutes.

The institutes were also having an effect upon the students. Teachers reported that they were able to enrich their own teaching. They encouraged students to engage in research and to work on projects suitable for science fairs and other contests. Many undertook the direction of the advanced placement program. All of the teachers felt that the information they received enabled them to be more effective in counseling and advising talented youngsters in careers in science and mathematics.

Many of the teachers were very modest in relating their contributions. This is exemplified by the statement of one teacher who wrote, "It is selfish to say this but the chief benefits are to me, enrichment, and this is not easy to pass on to another teacher. It finds its way into the teachers' lessons, however."

CONCLUSIONS

1. Science and mathematics teachers must be provided with the opportunity to keep up-to-date in their subject fields in order to keep pace with the rapid progress and changes which are taking place in these fields.

2. The institutes established by the National Science Foundation and other public and private educational foundations are accomplishing this important function.

3. To be effective the institute program must be enlarged to include all science and mathematic teachers and should be repeated periodically in order to keep the teachers at maximum professional competence.

4. The planning and direction of all institutes for high school teachers should be based upon the joint efforts of college and high school educators. Only by such joint action can good articulation be secured and can provision be made for the integration of the new subject matter into the high school science and mathematics classrooms. An NSF committee of college educators and high school directors and supervisors of science and mathematics should be appointed to consult with the directors of institutes.

5. A central agency should be established by the National Science Foundation which would work with the institutes in the processing of all applications. Such an agency could avoid duplications, could make a homogeneous selection of participants, could assure a sound geographical distribution of participants and could make selections which would provide adequate facilities for families.

6. All summer institutes should provide adequate periods for relaxation in order to enable teachers to start the new academic year rigorously and refreshed.

7. The National Science Foundation should appoint a committee to set up institutes for those who have completed one. Institutes should not only present a wide variety of subject matter and experiences to meet individual needs and differences among teachers but must also enable teachers to secure firmer foundation through institutes which have been planned to provide sequential training experiences.

8. The National Science Foundation should appoint a committee to draw up suggested bibliographies and lists of activities which teachers could use for self-enrichment and for the education and stimulation of talented youngsters interested in science and mathematics. Such publications should be revised annually. Suggestions for the use of new equipment and supplies as well as for various types of classroom, laboratory and storage facilities would prove extremely helpful to the high school educators and school officials.

9. The National Science Foundation should explore the possibility of supplementing its present institute program with teacher training via television.

10. Finally, there remains the realization that the most critical problem facing education today is the need for securing a sufficient number of well-trained teachers of science and mathematics to take care of the rising population of high school youngsters all over the country.

THE SCIENCE MANPOWER PROJECT

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THE Science Manpower Project was conceived in recognition of the fact that in the early fifties the flow of prospective scientific personnel through the schools and colleges had not been adequate to meet the needs of industry, government, the defense program, education, and other elements in the national economy. This was a pre-sputnik conclusion, and it came at a time when scientific manpower was not a subject of public concern. However, certain studies, which have been discussed in previous reports of the Science Manpower Project, led to the conclusion that scientific manpower was likely to be in increasingly short supply, and indicated that it was at the senior high school level that many students with potential scientific ability made decisions which inevitably channeled their interests into other areas of education and training.

Earlier reports of the Science Manpower Project also emphasized a growing shortage of properly qualified secondary school science teachers. Thus, a Progress Report to the Joint Industry-Education Advisory Council on December 12, 1956, made the prediction that such teachers would be in short supply in September of 1957; a forecast that was all too accurate. The 1956 report further indicated that the teacher supply would be somewhat more adequate in September, 1958, and this prediction also appears to have been justified. The 1956 report, moreover, emphasized that 1959 and 1961 would be peak years of science teacher demand, and at the present time we see no reason for doubting that this position was equally well taken.

PLAN OF ORGANIZATION

In planning the operation of the Science Manpower Project it was proposed to attack the general problem along two lines: (a) to effect improvement in the science program of the schools, and thus increase the flow of students with science aptitudes from secondary schools to colleges, and (b) to effect improvement in the teacher-training program designed to produce a larger and more effective corps of science teachers. The common-school science teachers are, of course, key figures in the science manpower problem, and so are the college teachers who train them.

The aforementioned plan required personnel to do the job, as well as financial support. To meet the first requisite, a plan was developed to bring to Teachers College, Columbia University, successive groups of Fellows representing teacher-training institutions in various parts of the country, to spend an academic year working upon various phases of the problem, and to assist in preparing materials necessary to the implementation of (a) and (b) in the preceding paragraph. Then, according to plan, the Fellows were to return to their various institutions, where they were to maintain a corresponding association with the project, and promote the development and use of its policies and materials. This plan has been continued in effect during the past three years, and has produced some unexpected results inasmuch as Fellows have not always returned to the institutions from which they came. In addition, it has proved desirable to appoint as Fellows certain experienced science teachers from the schools, to assist in course of study development. And last, but by no means least, other science educators and scientists who have not been Fellows of the project have joined the growing group of Associates from time to time. The project calls upon these Associates to review tentative courses of study and related materials, and the resulting evaluations are given very careful consideration. This policy of utilizing the assistance of a large number of experts in the field has the effect of giving the Science Manpower Project a national rather than a local frame of reference.

The list of science educators and scientists who have participated or are participating in the Science Manpower Project in the Associate relationship is as follows (April, 1959): Dr. Hugh Allen (New Jersey S.T.C. at Montclair), Dr. Francis J. Bernard (Iona College), Prof. N. E. Bingham (Univ. of Florida), Dr. Paul Blackwood (U.S. Office of Education), Prof. David Blick (Univ. of Connecticut), Dean Augusto Bobonis (Univ. of Puerto Rico), Prof. Roscoe F. Boyer (Univ. of Mississippi), Dr. Harry Brenowitz (Adelphi College), Dr. Ned Bryan (Rutgers Univ.), Prof. Guy P. Cahoon (Ohio State Univ.), Dr. Albert B. Carr (Univ. of Hawaii), Prof. John Chase (Univ. of North Carolina), Mr. Ralph Cullman (Wisconsin S.T.C. at Eau Claire), Dr. Peter M. Dean (Wayne State Univ.), Dr. Frank Eller (East Carolina St. Coll.), Dr. Harley F. Glidden (Colorado St. Coll.), Dean J. G. Harlow (Univ. of Oklahoma), Dr. Ellis Haworth (Dist. of Columbia T.C.), Mr. Rollin P. Hugny (Advanced Studies Program), Prof. Norborn Felton (San Jose St. Coll.), Dean John J. Fisher (Massachusetts S.T.C. at Lowell), Prof. Lee M. Harrison (Louisiana State Univ.), Dr. Trygve Jensen (Wagner College), Prof. Philip C. Johnson (Cornell Univ.), Dr. Roy Lee (Bennett College), Prof. Robert M. Morrow (Western Illinois Univ.), President R. S. Pitkin (Goddard College), Dr. George Pitluga (Univ. of New York S.T.C. at Oswego), Prof. T. R. Porter (St. Univ. of Iowa), Prof. Abraham Raskin (Hunter College), Dr. Francis J. Rio (Connecticut S.T.C. at New Britain), Prof. James Rutledge (Univ. of Nebraska), Prof. David S. Sarner (Temple Univ.), Dr. Herbert Schwartz (New York Univ.), Dr. James Silvan (Connecticut S.T.C. at New Haven), Prof. Herbert Smith (Univ. of Kansas), Dr. Herbert Stewart (Maryland S.T.C. at Towson), Dr. Robert Stollberg (San Francisco St. Coll.), Dr. Harold Tannenbaum (Univ. of New York S.T.C. at New Paltz), Dr. John Urban (Univ. of New York S.T.C. at Buffalo), Dr. Ismael Velez (Inter-American Univ.), Prof. Ralph Watkins (Univ. of Missouri), Prof. Fletcher Watson (Harvard Univ.), Dr. E. K. Weaver (Atlanta Univ.), Dr. John Wells (Madison College), Dr. Robert

Wickware (Connecticut S.T.C. at Willimantic), Dr. Leonard Winier (Iowa S.T.C.), Prof. Woodrow W. Wyatt (Univ. of Tennessee), Dr. Frank Yale (Arizona St. Coll.), and Dr. George Zimmer (Univ. of New York S.T.C. at Fredonia).

Financial support for the project has been provided by over twenty industries and industrial foundations. A Joint Industry-Education Advisory Council was formed during the first year of the project's existence, and has continued to hold semi-annual meetings. These meetings are devoted to a review of progress and to the analysis of future tasks. A Corresponding Industry-Education Advisory Council has also participated in policy reviews. Members of the academic community who have taken part in the deliberations of the Joint Industry-Education Advisory Council have been President Frank Bowles (College Entrance Examination Board), Dean John R. Dunning (Columbia University), Professor Ralph Halford (Columbia University), Professor Louis P. Hammett (Columbia University), President Morris Meister (Bronx Community College), and Dr. Howard Meyerhoff (Scientific Manpower Commission).

The working group at Teachers College, Columbia University during the past three years has included the Director and Two Associate Directors: Professors Hubert M. Evans and Willard J. Jacobson. Fellows who have participated for one or more years have been Dr. Hugh Allen Jr., Mrs. Frances Hall Behnke, Mr. Ralph E. Cullman, Dr. Albert B. Carr, Dr. Peter M. Dean, Dr. Frank Eller, Mr. Norborn M. L. Felton, Mrs. Renee Ford, Dr. Walter F. Gard, Mr. Rollin P. Hugny, Mr. Bernard T. Kingery, Mr. Donald E. Lee, Mr. J. Gordon Manzer, Mr. Lester C. Mills, Mr. Edward F. Pierce, Mr. Lawrence Pugno, Dr. Francis F. Rio, Professor Louis Sattler, Dr. Herbert H. Stewart, Mrs. Dorothy F. Stone, Mr. Richard Strawcutter, and Professor David Vitrogan.

COURSE OF STUDY REVISION

One of the efforts of the Science Manpower Project has been *to develop an articulated sequence of science courses with modernized content for grades K through twelve.* Tentative proposals for such courses are produced by the working group at Teachers College, Columbia University, and then forwarded to the Associates of the project for review. After suggestions for revisions have been received, the appropriate modifications of the tentative proposals are made. The modified proposals are subsequently reviewed by subject-matter experts to assure technical accuracy. Tentative courses of study are now ready for publication and tryout in the schools, after which it is anticipated that certain revisions will be effected.

By special arrangement the courses of study are sent to the member institutions of the Central School Boards Committee, the Associated Public School Systems, and the Metropolitan School Study Group. These three organizations represent some 700 school systems—large and small—in various parts of the country. The new courses of study are also supplied to the Associates and the teacher-training institutions which they represent.

Status of the course-of-study program on May 1, 1959 was as follows:

Modern High School Physics (David Vitrogan), published and distributed.

Modern High School Chemistry (Edward F. Pierce), undergoing final review.

Modern High School Biology (Dorothy F. Stone), undergoing final review.

Modern General Science (Abraham Fischler), ready for final review in the near future.

Modern Elementary Science (Willard J. Jacobson, Harold Tannenbaum and others), in preparation.

As they become available, monographs which present these courses of study may be obtained by purchase from the Bureau of Publications, Teachers College, Columbia University, New York 27, New York.

OTHER PROJECTS

Allied to the course of study monographs are a number of supporting studies, upon which reports have been or will be published by the Bureau of Publications, Teachers College, Columbia University. In this group are a teacher's handbook of modern chemical theory, a parallel handbook in physics, and a monograph on techniques for using the problem-solving method of instruction.

Now in press is a study by Dr. Hugh Allen Jr., entitled *Attitudes of Certain High-School Seniors Toward Science and Scientific Careers,* which examines various stereotypes affirmed by the respondent group, and compares them with the attitudes affirmed by a jury of scientists. Dr. Allen is currently conducting a follow-up study of the same student group to determine the extent to which their expressed attitudes and vocational objectives have changed with the passage of time.

In the published category is a monograph by Dr. Frank W. Eller entitled *A Guide to Engineering Education.* This volume is designed to provide information of value to high-school students who plan careers in engineering, and also the science teachers who are called upon to plan the programs of such students.

Scheduled for the coming year is a policy report on the organization and administration of science programs. During the past three years it has been apparent that the desire to improve science education in the schools exists, but that a general program for effecting such improvement has not been readily available to boards of education, superintendents, principals and teachers. In fact, the Science Manpower Project received so many requests for aid in this area that the need for a general policy report became self-evident. Substantial progress has been made in preparing this rather extensive monograph. It represents the combined efforts of a number of science educators, scientists, and teachers, and deals with such matters as policy formulation, existing science programs, the need for scientific personnel, external and internal problems of science education, administration of science programs, the elementary science program, the general science program, the problem in biology, the problems in physics, chemistry and physical science, and programs and policies for teacher training.

THE CHANGING PICTURE OF SCIENCE EDUCATION

In the post-sputnik period an aroused public consciousness and the efforts of various organizations, including the Science Manpower Project, have had impacts upon the school science program. Individuals from many walks of life have shown a disposition to "get in the act," and although the resulting clamor has sometimes been characterized more by fury than by logic, its general effect has been constructive: it has focused public attention upon the need to improve instruction in general, and instruction in science and mathematics in particular.

Meanwhile, rather substantial increases in high school science enrollments appear to be in progress. These enrollments represent student elections of science courses for the most part, and they were at a very unsatisfactory level in 1952–53, especially in the cases of physics and chemistry. Recent figures compiled by the United States Office of Education, and so far based upon samples of the school population, indicate that considerably larger percentages of high-school students are now enrolling in biology, physics and chemistry. This trend is gratifying, and it suggests that college enrollments in the sciences and technical sciences may take an upward turn in the years just ahead. It is perhaps too soon, however, to make hard and fast predictions that this will occur.

It is one thing, of course, to induce students to enroll in science courses; it is another to provide challenging instruction that will maintain and build student interests. To do the latter we still need to make progress in the schools along three general lines:

1. To provide adequate physical facilities for instruction, which are sub-standard in many schools of the nation. This need does not apply to science instruction alone.
2. To modernize and improve the science curriculum in such a manner that the resulting sequence is a series of continuously challenging courses.
3. To provide a more effective program of teacher training, and continue and extend existing programs of in-service training, with a view to developing a larger and more adequate teaching corps. This need is of particular importance at the elementary school level, since many elementary school teachers have had little formal education in the sciences.

To put it another way, further effort must be expended before we can be assured that the science program of the schools has made a substantial and permanent advance. At present, there are indications that better physical facilities for instruction will be made available in many communities. New courses of study are under preparation, and revised text books and manuals probably will be forthcoming along with other new teaching aids. But courses of study and teaching aids can never remain static; they must be revised and replaced more frequently than has been the case in the past. This can be done if we see the importance of the task and elect to make the effort.

Developing a more adequate corps of science teachers is likely to present greater difficulties. The plain fact is that college graduates with majors in the sciences, and especially the physical sciences, have been in short supply for a number of years. Such graduates are in demand by industry and the various agencies of government, and some of them continue in graduate work despite the efforts of would-be employers. Far too few become available as prospective high school teachers, which is one reason why it is difficult to find prospective teachers fully qualified in the subject matter. In fact, a shortage of qualified college science teachers also appears to be in the offing, even though the large, anticipated increase in college population lies a few years in the future.

The problem of science teacher supply must be solved because future supplies of scientific manpower depend upon that solution. If the present enhanced interest in high school science courses is continued at the college level during the ensuing four years the problem may cease to exist. Otherwise, special inducements to undertake careers in science teaching may become a national necessity.

AN INDEPENDENCE STUDY OF CHOICE OF SCIENCE OR NON-SCIENCE MAJOR AS RELATED TO ABILITY AND INTEREST TEST SCORES

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THERE has been much recent concern in this country with the problem of science education. There is little doubt that this nation has at the present time a shortage of trained scientific personnel, a shortage of which there is likely to be little alleviation unless our colleges and universities begin to turn out a larger number of science graduates than they are now doing. It is, of course, axiomatic that colleges will not produce these graduates unless more able young people attend these institutions and enroll in science curricula. The problem is two-fold: more able young people must attend college, and, of these, more must have or must be encouraged to develop an interest in scientific pursuits. The present study is concerned with the investigation of certain aspects of the second phase of this problem.

PURPOSE OF THE STUDY

There are a number of questions surrounding the problem as posed above upon which research must be brought to bear. Two pertinent questions are: Are science fields attracting an equitable proportion of the able students now enrolling in college? Is interest a potent factor in choice of a science or non-science major for able students? The present study is designed to provide information pointed toward answers to these questions. Tabular data will be presented showing the division of a second-semester college freshman class as to science or non-science major by ability test score quartiles. Tabular data will be presented showing by ability test quartile the proportion of both science and non-science majors having above and below average interest in scientific and computational pursuits. The chi-square test for independence of attributes will be applied in each case.

SUBJECTS AND TESTS

The subjects involved in the present study constitute the entire class of second semester freshmen at Panhandle A. and M. College during the spring term of 1957. These number 170. The quantitative reasoning score (q-score) of the American Council on Education Psychological Examination was taken as a measure of the kind of academic ability important to success in science curricula. All quartile divisions shown in the tabular data of this study are based upon the all-college norms provided by the publishers of this test. Measures of scientific and computational interests were taken from the scales by the same names on the adult form of the Kuder Interest Inventory. Students were judged to have above average or below average interests of these types strictly according to the norms provided by the publishers of this test. Persons indicating on their enrollment forms majors in chemistry, physics, mathematics, engineering, general science, geology, biological science, pre-medical, or nursing were considered to be science majors. All other fields were classified as non-science. The fact that the study was made in a small college situation simplified the classification problem considerably.

RESULTS OF THE STUDY

Table I shows the number of science and the number of non-science majors found in each ability quartile. The numbers in parentheses indicate the distribution to be expected if choice of major and ability were independent of one another.

From the data in the above table it would appear that science students are in the minority in this freshman class. However, there is no basis for assuming that students should divide themselves equally between science and non-science fields; instead, it is more important to ascertain whether or not there is a tendency for choice of a science major to be associated with ability and for science fields to be reasonably attractive to able students. From the size of chi-square in the above data the null hypothesis of independence of choice of major and ability

TABLE I

DISTRIBUTION OF SCIENCE AND NON-SCIENCE MAJORS ACCORDING TO ABILITY QUARTILE

	A.C.E. Q-Score Quartile				
Major	1	2	3	4	Total
Science	5 (12.4)	16 (14.6)	13 (12.8)	12 (6.2)	46
Non-science	41 (33.6)	38 (39.4)	34 (34.2)	11 (16.8)	124
Total	46	54	47	23	170

Chi-square = 13.63 P = .01

TABLE II

SCIENTIFIC INTEREST AMONG SCIENCE AND NON-SCIENCE MAJORS

Major	Above Average	Below Average	Total
Science	34 (22.7)	12 (23.3)	46
Non-science	50 (61.3)	74 (62.7)	124
Total	84	86	170
	Chi-square = 13.95	P = .01	

TABLE III

COMPUTATIONAL INTEREST AMONG SCIENCE AND NON-SCIENCE MAJORS

Major	Above Average	Below Average	Total
Science	32 (21.4)	14 (24.6)	46
Non-science	47 (57.6)	77 (66.4)	124
Total	79	91	170
	Chi-square = 12.20	P = .01	

TABLE IV

SCIENTIFIC INTEREST AMONG SCIENCE AND NON-SCIENCE MAJORS ACCORDING TO ABILITY QUARTILE

Major	Above Average	Below Average	Total
	First Quartile		
Science	4 (1.8)	1 (3.2)	5
Non-science	13 (15.2)	28 (25.8)	41
Total	17	29	46
	Chi-square = 2.83	P = .09	
	Second Quartile		
Science	8 (7.7)	8 (8.3)	16
Non-science	18 (18.3)	20 (19.7)	38
Total	26	28	54
	Chi-square = .00	P = .95+	
	Third Quartile		
Science	13 (7.5)	0 (5.5)	13
Non-science	14 (19.5)	20 (14.5)	34
Total	27	20	47
	Chi-square = 10.92	P = .01	
	Fourth Quartile		
Science	9 (7.3)	3 (4.7)	12
Non-science	5 (16.7)	6 (4.3)	11
Total	14	9	23
	Chi-square = 1.07	P = .30	

would have to be rejected, and it would therefore appear that science is drawing in a more than equitable fashion from among the higher ability groups.

Tables II and III are revealing of the scientific and computational interests of science and non-science majors and offer comparison data. The figures in parentheses represent the numbers to be expected in each category if scientific interest and choice of major were independent of one another.

From the data in the tables above and the highly significant chi-squares obtained, it may definitely be seen that the choice of a science or non-science major is not independent of interest in scientific and computational pursuits as measured by the Kuder. In view of the wide use and accepted validity of this test, it would have been surprising if the findings had been otherwise. However, these data may be construed as further evidence attesting to the fact that interest can and does influence the choice of a major field.

Tables IV and V show by ability quartiles the number of science and non-science majors having above average and below average scientific and computational interest respectively. The numbers in parentheses again represent the numbers to be expected in each category if interest and choice of major were independent. All chi-squares shown have been adjusted according to the

TABLE V

COMPUTATIONAL INTEREST AMONG SCIENCE AND NON-SCIENCE MAJORS ACCORDING TO ABILITY QUARTILE

Major	Above Average	Below Average	Total
	First Quartile		
Science	3 (1.9)	2 (3.1)	5
Non-science	14 (15.1)	27 (25.9)	41
Total	17	29	46
	Chi-square = .34	P = .60	
	Second Quartile		
Science	10 (6.5)	6 (9.5)	16
Non-science	12 (15.5)	26 (22.5)	38
Total	22	32	54
	Chi-square = 3.32	P = .07	
	Third Quartile		
Science	11 (8.0)	2 (5.0)	13
Non-science	18 (21.0)	16 (13.0)	34
Total	29	18	47
	Chi-square = 2.60	P = .11	
	Fourth Quartile		
Science	8 (5.7)	4 (6.3)	12
Non-science	3 (5.3)	8 (5.7)	11
Total	11	12	12
	Chi-square = 2.27	P = .14	

recommended practice for two by two fold tables containing a small number of entries.

When considering the values of chi-squares yielded by the sub-groups shown in Tables IV and V one should consider that these values are really divisive of the highly significant chi-squares obtained from the data in Tables II and III since the earlier tables contained the entire population from which the sub-groups came. Nevertheless, in the majority of instances among these ability sub-groups it may be seen that the probability of independence of interest and choice of major is small. Those probabilities obtained for the upper quartiles are perhaps worthy of special note since it is likely that those who succeed in eventually graduating in a science field are likely to come preponderantly from these groups. These probabilities were .01, .30, .11, and .14. This is indicative that interest is an important factor affecting choice of a science or non-science major among those potentially most able.

CONCLUSIONS AND GENERALIZATIONS

From the data derived in the present study the following conclusions and generalizations would appear warranted:

(1) Quantitative reasoning ability and choice of a science or non-science major are not independent of one another. Interpretation of the tabular data of this study supports the conclusion that science fields are now drawing in a more than equitable fashion from among students of higher ability. This finding supports the conviction held by many persons concerned with the problem of science education that one way to insure the production of more trained scientists is through programs which will make it economically feasible for all able students to attend college without stipulation of major field to be studied.

(2) Choice of a science or non-science major is not independent of interest in scientific and computational pursuits as measured by a standardized interest inventory. Interest therefore remains as a potent factor influencing choice of field. This finding would support the convictions of those who feel that one way of attacking the shortage problem is through the encouragement and development of scientific interest among the pre-college youth.

(3) Although conclusions one and two are true, there exists among the present college freshman population a reservoir of able students who have above average interest in scientific and computational pursuits, but who are planning to major in non-scientific fields. It is possible that with appropriate guidance and a certain degree of promotional evangelism by science departments a number of these students might change to a science major. This is not to imply that unrestricted pirating is to be condoned as a justifiable practice, but simply that science personnel should promote their cause among this group by all means which are ethical.

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A STUDY OF THE INDEPENDENCE OF CHOICE OF SCIENCE OR NON-SCIENCE MAJOR AND MEASURES OF PERSONALITY TRAITS

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IT would be a gross understatement to say that there has been much current concern over the problem of science education in this country. This concern has resulted in a proliferation on opinions expressed in published and unpublished form, but what is more important has resulted in an emphasis on research and experimentation related to the different phases of the problem. These research efforts have been primarily directed toward the improvement of science instruction and the identification and encouragement of science talent. The present research is in the latter category.

The opinion has often been expressed (sometimes in a derogatory fashion) that science people are somehow "different" from others. The difference inferred being in the realm of personality attributes. A number of recent polls of the public and of young people have revealed a number of stereotyped notions and impressions of what the scientist is like personality-wise. Some well designed and significant research has been done shedding light upon the ways in which the personality attributes of creative scientists differ from those of the normal population. Worthy of note is the work of Drevdahl and Cattell [1, 2], who after studying a group of creative scientists in comparison with a group representative of the normal population, reported that the creative group differed from the normal in being somewhat more intelligent, emotionally sensitive, dominant, adventurous, emotionally mature, introverted, radical, self-sufficient, and less subject to group control. Conformity, concern for propriety, and adherence to social standards and dictates were reported to be somewhat lacking in the creative scientist group.

One wonders whether such findings would extend downward into the educational program and apply to any extent to a novice group of budding scientists. One wonders if perhaps differences in personality may affect the choice of a science versus a non-science major program or if these differences found by Drevdahl and Cattell are the result of a regimen of training and experience. The present study seeks information directed toward answering these questions.

The present study specifically seeks to find if there are identifiable differences in personality attributes as measured by a standard personality inventory of freshman and sophomore students enrolled in science curricula and those freshman and sophomore students enrolled in other curricula.

PROCEDURE

The subjects involved in the study constituted the entire freshman and sophomore class of regularly enrolled students during the 1957–58 school year at Panhandle A. and M. College for whom complete test data and enrollment information were available. These students numbered 251, of whom 56 were science majors and 195 were majors in other fields. Persons indicating on their enrollment forms majors in chemistry, physics, mathematics, engineering, general science, geology, biological science, pre-medical, pre-dental, pre-veterinary, or pre-nursing were considered to be science majors. All other fields were classified as non-science. The fact that the study was made in a small college situation simplified the classification problem.

The Guilford-Zimmerman Temperament Survey was used as a measure of personality attributes. The survey provides for measurement of personality along ten different trait dimensions: inactive and slow vs. ener-

TABLE I

DISTRIBUTIONS OF MEASURES OF PERSONALITY TRAITS OF SCIENCE AND NON-SCIENCE MAJORS

Major	First Quartile	Second Quartile	Third Quartile	Fourth Quartile	Total
		Inactive vs. Energetic			
Science	14 (14.73)	13 (15.17)	14 (14.73)	15 (11.38)	56
Non-Science	52 (51.30)	55 (52.83)	52 (51.30)	36 (39.62)	195
Total	66	68	66	51	251
		Chi-Square = 2.24	P = .50		
		Impulsiveness and Rhathymia vs. Seriousness and Restraint			
Science	16 (13.16)	7 (13.83)	23 (19.41)	10 (9.54)	56
Non-Science	43 (45.84)	55 (48.17)	64 (67.60)	33 (33.41)	195
Total	59	62	87	43	251
		Chi-Square = 5.97	P = .05		
		Submissive vs. Dominant			
Science	17 (17.85)	7 (18.52)	25 (14.73)	7 (4.91)	56
Non-Science	63 (62.15)	76 (64.48)	41 (51.27)	15 (17.09)	195
Total	80	83	66	22	251
		Chi-Square = 20.06	P = .01		
		Shy vs. Sociable			
Science	14 (13.39)	18 (17.85)	17 (17.40)	7 (7.36)	56
Non-Science	46 (46.61)	62 (62.15)	61 (60.60)	26 (25.64)	195
Total	60	80	78	33	251
		Chi-Square = .07	P = 95+		
		Emotional Instability and Depression vs. Stability			
Science	18 (14.95)	18 (17.63)	12 (14.28)	8 (9.15)	56
Non-Science	49 (52.05)	61 (61.37)	52 (49.72)	33 (31.85)	195
Total	67	79	64	41	251
		Chi-Square = 1.47	P = .70		
		Hypersensitiveness vs. Objectivity			
Science	12 (15.39)	15 (15.17)	19 (17.18)	10 (8.25)	56
Non-Science	57 (53.61)	53 (52.83)	58 (59.82)	27 (28.75)	195
Total	69	68	77	37	251
		Chi-Square = 1.69	P = .65		

TABLE I—*Continued*

Major	First Quartile	Second Quartile	Third Quartile	Fourth Quartile	Total
		Hostility vs. Friendliness			
Science	12 (7.59)	12 (12.49)	19 (20.30)	13 (15.62)	56
Non-Science	22 (26.41)	44 (43.51)	72 (70.70)	57 (54.38)	195
Total	34	56	91	70	251
		Chi-Square = 4.00	P = .25		
		Unreflectiveness vs. Thoughtfulness and Reflectiveness			
Science	9 (9.82)	15 (15.84)	19 (19.19)	13 (11.16)	56
Non-Science	35 (34.18)	56 (55.16)	67 (66.81)	37 (38.84)	195
Total	44	71	86	50	251
		Chi-Square = .54	P = .90		
		Criticalness and Intolerance vs. Cooperativeness			
Science	11 (8.70)	13 (16.96)	17 (18.29)	15 (12.05)	56
Non-Science	28 (30.30)	63 (59.04)	65 (63.71)	39 (41.95)	195
Total	39	76	82	54	251
		Chi-Square = 3.02	P = .40		
		Masculinity vs. Femininity			
Science	11 (12.94)	9 (14.06)	21 (17.85)	15 (11.16)	56
Non-Science	47 (45.06)	54 (48.94)	59 (62.15)	35 (38.84)	195
Total	58	63	80	50	251
		Chi-Square = 5.14	P = .15		

getic, impulsiveness and rhathymia vs. restraint and seriousness, submissive vs. dominant, shy vs. sociable, emotional instability and depression vs. stability, hypersensitiveness vs. objectivity, hostility vs. friendliness, unreflectiveness vs. thoughtfulness and reflectiveness, criticalness and intolerance vs. cooperativeness, and masculinity vs. femininity.

The study was designed as a test of the independence of two variables. In this case, the variables are personality and choice of major. In the presentation of the data, personality classification was made by quartiles and contingency tables constructed. Independence values were calculated and the chi-square test for refutation of the null hypothesis of independence was employed. This treatment was applied for each of the ten personality trait continuums.

RESULTS OF THE STUDY

Table I shows in concise form the entire data of the study. The table is constructed in such a fashion that one may note the distributions of science and non-science majors by norms quartiles on each of the ten different traits in succession. The numbers in parentheses show the numbers to be expected in each category under the hypothesis of independence. The probability (P) values indicate the relative frequency one would expect to obtain a chi-square as large as the one obtained if the two variables were completely independent. One notes that in most instances the probabilities are high forcing retention of the null hypothesis of independence.

From the size of the chi-squares and their associated probabilities the null hypothesis of independence must be retained for the trait measures of activity and energy level, shyness vs. sociability, emotional instability vs. stability, hypersensitiveness vs. objectivity, hostility vs. friendliness, unreflectiveness vs. thoughtfulness and reflectiveness, criticalness vs. cooperativeness, and masculinity vs. femininity.

On the other hand, significant chi-squares were obtained (probabilities of .05 and .01) in the case of the traits of impulsiveness and rhathymia vs. seriousness and restraint and submissiveness vs. dominance. In regard to these two traits the null hypothesis of independence of personality trait scores and choice of major will have to be refuted and a hypothesis of relatedness substituted. Proper statistical inference will not permit generalization further than this; however, logical inference is permissible. It would appear from the tabular data that in the case of the trait of impulsiveness vs. restraint that science majors tend not to be moderately impulsive, but tend to be either definitely impulsive or moderately restrained and serious as compared with other students. In the case of the trait of submissiveness vs. dominance, it would appear that science majors have a definite tendency toward being more dominant than other students.

The present study corroborates the findings of Drevdahl and Cattell concerning the traits of impulsiveness and dominance indicating that these are more present in scientists than in non-scientists early in their careers and raises the possibility that these traits may in some way affect the choice of a field of study. The present study does not find comparable differences in certain other traits such as emotional sensitivity and introversion (thoughtfulness and reflectiveness). The finding of these above authors citing the greater degree of intelligence of creative scientists was corroborated in earlier study by the present author showing that science fields tend to draw in a more than equitable fashion from the population of bright students [3].

SUMMARY AND CONCLUSIONS

From the data derived in the present study the following conclusions would appear warranted. Freshman and sophomore students who choose science majors do not differ from students who major in other fields in personality as measured by a standard personality inventory (Guilford-Zimmerman Temperament Survey) in the traits of: inactive vs. energetic, shyness vs. sociability, emotional instability vs. stability, hypersensitiveness vs. objectivity, hostility vs. friendliness, unreflectiveness (extroversion) vs. thoughtfulness and reflectiveness (introversion), criticalness vs. cooperativeness, and masculinity vs. femininity. Science and non-science majors do differ in two other personality traits with science majors tending to be either definitely impulsive or to be moderately serious and restrained and tending to be more dominant than submissive as a group than non-science majors.

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THE ACADEMIC AND TEACHING BACKGROUNDS OF SECONDARY SCIENCE TEACHERS IN THE STATE OF OHIO

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SCIENTIFIC developments of considerable note during 1957 and the first half of 1958 have had great influence upon the thinking of governmental, industrial, educational, and research leaders in the United States. From an analysis of published comments by these national figures, it is evident that a general feeling of dissatisfaction exists with the science education programs currently offered by the high schools of America. Many reasons have been postulated for the small enrollments and seeming lack of interest in the laboratory science offerings of these schools. One heard frequently is that the instructors of science courses have inadequate academic backgrounds and are therefore not qualified to teach in this area. Whether or not the academic backgrounds of these instructors have a bearing upon the problem must be determined from data obtained by research in the field.

This investigation of the academic and teaching backgrounds of secondary science teachers in the State of Ohio was concerned with a study of data relevant to the college(s) attended, semester hours of credit earned in professional education and in the five major areas of science, type of teaching certificate held, status as a science teacher, science subjects taught, number of years in present and former teaching position(s), and 1957–58 salary.

The procedures used in this study for securing data pertinent to the problem involved three steps. They were:

1. *Compilation of the Sample.* The sample consisted of the teachers in the high schools—121 in Northwestern Ohio and 38 from the random sample—which supplied data on science offerings, enrollments, and teacher assignments used by this investigator in the study entitled "The Status of Secondary Science Education in the State of Ohio" [3] and those in an additional 32 high schools selected from the state at large by using the random selection process.

2. *Securing Data on Each Teacher in the Sample.* This involved either one, two, or three steps. (1) Data were obtained from the principal's 1957–58 reports on file at the State Department of Education, Columbus. (2) Since many instances were found where the principal had failed to give a breakdown of the comprehensive science major or minor fields, an inquiry form was mailed to the individual principal, executive head, or superintendent with the request that he copy directly from the teacher's transcript the actual number of semester hours of credit earned in the fields of biology, chemistry, physics, geology, and astronomy. (3) Failing to receive a response from the school's administrative officer, an inquiry form requesting the science breakdown was sent directly to the registrar of the college from which the teacher was graduated.

3. *Tabulation of All Data.* Information was transferred from the forms used in collecting data at the State Department of Education and from the inquiry forms to IBM cards. These were sorted and totaled on IBM machines. Classification categories were based upon school size, part-time or full-time status of the science teacher, and the science subjects taught.

In this report, a full-time teacher is considered to be one who teaches only in the various fields of science. A part-time teacher is one who teaches one or more science course(s) and some non-science subject(s).

Inasmuch as the data collected covered several aspects of each science teacher's pro-

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file, the findings were divided into three categories; namely, (1) those associated with the acquisition of a college education; (2) those associated with the teaching background; and (3) those associated with academic preparation in science. The major findings will be presented in this sequence.

FINDINGS ON COVERAGE AND COLLEGIATE BACKGROUND

The compiled data pertinent to this portion of the study showed that 476 instructors were offering science courses in the 175 high schools from which complete information was obtained. This represented roughly an 18 per cent coverage of the senior, four-year, and six-year high schools operating in Ohio during the 1957–58 academic year. Two-hundred-ninety-four of these instructors were classified as part-time and 182 as full-time.

Approximately 83 per cent of the science teachers were graduated from Ohio colleges or universities. Slightly more than one-half of the instructors had completed some graduate work, and roughly one-third of them held master's degrees. It was observed, however, that a higher percentage of full-time science instructors had completed graduate work and a master's degree program than their part-time counterparts.

Interpretation of data which dealt with the year of graduation from college divulged that the median year for all of the teachers was 1947; for the part-time group, 1949; and for the full-time group, 1941. The extremes showed that 30 teachers were graduated in 1957 and 16 had been graduated in the 1910–19 category. Eleven part-time teachers had not completed the requirements for the baccalaureate degree, while all of the full-time group had received their bachelor's degree.

Since 24 seemed to be a reasonably accurate estimate of age for graduation from college, it followed that the median age of the science instructors was 35. A breakdown into part-time and full-time teachers showed that 33 was the median age for the former group and 41 for the latter group. It was further noted that a majority of the younger part-time instructors were employed in high schools having enrollments of less than 200, while the majority of mature full-time instructors were teaching in schools having a student body of 500 or more.

Except for 32 teachers, the professional education backgrounds of the science instructors consisted of 16 or more semester hours of credit in education courses. The median was 27.5; the mean was 31.8; and the mode was located in the 23–25 category.

FINDINGS ON TEACHING BACKGROUND

The compiled data pertinent to this portion of the study showed that 53 per cent of the science instructors were teaching on four-year provisional certificates, and an additional 26 per cent held the permanent type certificate. Sixty-two or 13 per cent held eight-year professional certificates, and 30 or approximately 6 per cent were teaching on temporary certificates.

A further analysis of data revealed that about two-thirds of the science instructors had been on their present jobs for five years or less. Approximately 37 per cent were completing the first year in their current locations. On the other hand, 16 per cent had been in their present positions for more than 15 years. The median number of years of experience in the current positions was 2.75; the mean was 6.25.

It was further noted that about one-third of the science teachers had no previous teaching experience, but roughly 10 per cent had prior experience in excess of 16 years. The median number of years of prior experience was five; the mean was 4.9.

The most prevalent salaries paid Ohio science teachers were in the $4,000–$5,900 range. For straight teaching, the lowest was a part-time teacher in the 1–199 enrollment category receiving $3,000; the highest was a full-time teacher in the 500–999 enrollment category receiving $7,000. The median salary paid for the 1957–58 academic year was $4,700; the mean was $4,890.

FINDINGS ON ACADEMIC PREPARATION IN SCIENCE

Teachers of General Science. There were 129 part-time and 86 full-time teachers offering general science in the 175 high schools investigated. Approximately 98 per cent of these teachers had some science credits in their collegiate backgrounds. This varied all the way from three semester hours in each of two areas to 103 in five areas. The median number of credits earned by the 215 general science teachers in the combined science areas was 36. Divided into part and full-time groups, their respective medians were 29 and 43.

Roughly 75 per cent of the general science instructors had 21 or more credits in science, but the nature and depth of the areas pursued varied greatly. A breakdown by subject fields follows:

(a) Biology was included in the academic backgrounds of 80 per cent of the general science teachers. The median number of credits earned was 19. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 21 to 17 respectively. Slightly more than one-third had 10 credits or less and about one-fifth had 31 or more.

(b) Chemistry was included in the academic backgrounds of 71.6 per cent of the general science teachers. The median number of credits earned was 14. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 18 to 13 respectively. Fifty-two and one-half per cent had 10 credits or less and 18 or 8.4 per cent had 31 or more.

(c) Physics was included in the academic backgrounds of 61 per cent of the general science teachers. The median number of credits earned was nine. A few more full-time teachers had completed work in physics than their part-time counterparts, but both of their medians were nine. Seventy-six per cent had 10 credits or less, and three or 1.4 per cent had 31 or more.

(d) Geology was included in the academic backgrounds of 20 per cent of the general science teachers. The median number of credits earned was five. Part-time teachers had earned almost twice the number of hours as their full-time counterparts. The ratio between their medians was seven to four respectively. Ninety-seven and six-tenths per cent had 10 credits or less.

(e) Astronomy was included in the academic backgrounds of six per cent of the general science teachers. The median number of credits earned was four.

These findings indicated that general science teachers as a whole had relatively broad science backgrounds and an average depth of approximately 36 semester hours of credit. Full-time teachers were on the whole better prepared than part-time teachers. The areas of preparation arranged according to their descending strengths were: biology; chemistry; physics; geology; and astronomy, with the latter being absent in 94 per cent of the cases.

Teachers of Biology. There were 143 part-time and 97 full-time teachers offering biology in the 175 high schools investigated. Approximately 99 per cent of these teachers had some science credits in their collegiate backgrounds. This varied all the way from six semester hours in one area to 110 credits in three. The median number of credits earned by the 240 biology teachers in the combined science areas was 33. Divided into part and full-time groups, their respective medians were 28 and 45.

Seventy-five per cent of the biology instructors had 21 or more credits in science, but the nature and depth of the areas pursued varied greatly. A breakdown by subject fields follows:

(a) Biology was included in the academic backgrounds of 97.1 per cent of the instructors teaching this subject. The median number of credits earned was 24. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 28 to 22 respectively. Slightly more than one-tenth had 10 credits or less, and roughly three-tenths had 31 or more.

(b) Chemistry was included in the academic backgrounds of 51 per cent of the biology teachers. The median number of credits earned was 13. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 17 to 12 respectively. Seventy per cent of the biology teachers had 10 credits or less, and only 3.33 per cent had 31 or more.

(c) Physics was included in the academic backgrounds of 32 per cent of the instructors teaching biology. The median number of credits earned was nine. More full-time than part-time teachers had taken work in physics, but the median for both groups was nine. Approximately 88 per cent had

10 credits or less, and none of these teachers had completed as many as 31 semester hours in physics.

(d) Geology was included in the academic backgrounds of 16.7 per cent of the biology teachers. The median number of credits earned was four. Part-time teachers had earned on the average more credits in this science field than their full-time counterparts. The ratio between their medians was five to four respectively.

(e) Astronomy was included in the academic backgrounds of 4.2 per cent of the instructors teaching biology. The median number of credits earned was four.

These findings indicated that biology teachers as a whole had relatively adequate academic backgrounds with an average depth of approximately 33 semester hours of credit in the combined fields of science. Included in this average were about 24 credits in biology. Full-time teachers were on the whole better prepared than part-time teachers. The areas of preparation arranged according to their descending strengths were: biology; chemistry; physics; geology; and astronomy.

Teachers of Chemistry. There were 108 part-time and 67 full-time teachers offering chemistry in the 175 high schools investigated. Ninety-nine and one-half per cent of these teachers had some science credits in their collegiate backgrounds. This varied all the way from 11 semester hours in one area to 103 in five. The median number of credits earned by the 175 chemistry teachers in the combined science areas was 48. Divided into part and full-time groups, their respective medians were 46 and 54.

Seventy-five per cent of the chemistry instructors had 32 or more credits in science, but the nature and depth of the areas pursued varied greatly. A breakdown by subject fields follows:

(a) Biology was included in the academic backgrounds of 72.5 per cent of the instructors teaching chemistry. The median number of credits earned was 19. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 23 to 17 respectively. Roughly one-half of the teachers had 10 credits or less, and almost 18 per cent had 31 or more.

(b) Chemistry was included in the academic backgrounds of 96.5 per cent of the teachers offering this subject. The median number of credits earned was 19. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 20 and 18 respectively. Twenty-two per cent of the chemistry teachers had 10 credits or less, and 32 or 18.3 per cent had 31 or more.

(c) Physics was included in the academic backgrounds of 77.7 per cent of the instructors teaching chemistry. The median number of credits earned was 12. Approximately the same number of part and full-time teachers had taken work in physics, but their respective median number of credits was 11 and 12. Fifty-nine per cent had 10 credits or less and only one had 31 or more.

(d) Geology was included in the academic backgrounds of 18.9 per cent of the chemistry teachers. The median number of credits earned was five. A higher percentage of the full-time teachers had completed work in geology, but the median number of credits earned by both groups was five.

(e) Astronomy was included in the academic backgrounds of 10 per cent of the instructors teaching chemistry. The median number of credits earned was four.

These findings indicated that chemistry teachers as a whole had credits in two and one-third science areas, thus providing them with relatively broad science backgrounds. The average depth of preparation was about 48 semester hours of credit in the combined fields of science. Included in this average were roughly 19 credits in chemistry. Full-time teachers on the whole were better prepared than part-time teachers. The areas of preparation arranged according to their descending strengths were: chemistry; biology; physics; geology; and astronomy.

Teachers of Physics. There were 47 part-time and 37 full-time teachers offering physics in the 175 high schools investigated. Approximately 99 per cent of these teachers had some science credits in their collegiate backgrounds. This varied all the way from six semester hours in one area to 103 in five. The median number of credits earned by the 84 physics teachers in the combined science areas was 47. Divided into part and full-time groups, their respective medians were 43 and 54.

Seventy-five per cent of the physics instructors had 33 or more credits in science, but the nature and depth of the areas pursued varied greatly. A breakdown by subject fields follows:

(a) Biology was in the academic backgrounds of 62 per cent of the instructors teaching physics. The median number of credits earned was 19. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 20 and 18 respectively. Forty-three or 51.2 per cent of the teachers had 10 credits or less, and 9.5 per cent had 31 or more.

(b) Chemistry was included in the academic backgrounds of 91.7 per cent of the teachers offering physics. The median number of credits earned was 18. Full-time teachers had earned more hours than their part-time counterparts. The ratio based on their medians was 19 to 16 respectively. Thirty-one per cent had 10 credits or less, and 11 or 13.1 per cent had 31 or more.

(c) Physics was included in the academic backgrounds of 91.7 per cent of the instructors teaching this subject. The median number of credits earned was 13. Even though a higher percentage of the full-time teachers had completed work in physics, the median number of credits earned by each group was the same; namely, 13. Forty and one-half per cent had 10 credits or less, and seven or 8.3 per cent had 31 or more.

(d) Geology was included in the academic backgrounds of 15.5 per cent of the physics teachers. The median number of credits earned was seven. Part-time teachers had earned on the average more credits in this science field than their full-time counterparts. The ratio between their medians was seven to six respectively.

(e) Astronomy was included in the academic backgrounds of 9.5 per cent of the instructors teaching physics. The median number of credits earned was three.

These findings indicated that physics teachers as a whole had credits in two and one-fifth science areas, thus providing them with relatively broad science backgrounds. The average depth of preparation was about 47 semester hours of credit in the combined fields of science. Included in this average were roughly 13 credits in physics. Since both the part and full-time teachers of physics had a median number of 13 credits in this science subject, each group had equal preparation. The areas of preparation arranged according to their descending strengths were: biology; chemistry; physics; geology; and astronomy.

The Complete Science Teacher's Profile. Based upon the findings in parts one, two, and three, a profile, representing the typical secondary school science teacher in Ohio, looks something like this: He is a graduate of an Ohio institution of higher education; completed the baccalaureate degree in 1947 so is therefore approximately 35 years of age; has pursued some in-service graduate work; has completed roughly 27 semester hours of credit in professional education; has a four-year provisional teaching certificate; has, based upon the "mean," approximately 11 years of teaching experience—six in his present position and five in prior position(s); and receives an academic year salary of about $4,900.

Since the academic preparation in science varied with each subject taught, the remainder of a typical science teacher's profile was derived for each of the four fields; namely, (1) general science; (2) biology; (3) chemistry; and (4) physics.

(1) He has earned a median of 36 credits in two areas of science. His major concentration of credits is in biology and chemistry with medians of 19 and 14 respectively.

(2) He has earned a median of 33 credits in one and one-fourth areas of science. His major concentration of credits is in biology and chemistry with medians of 24 and 13 respectively.

(3) He has earned a median of 48 credits in two and one-third areas of science. His major concentration of credits is in chemistry and physics with medians of 19 and 12 respectively.

(4) He has earned a median of 47 credits in two and one-fifth areas of science. His major concentration of credits is in chemistry and physics with medians of 18 and 13 respectively.

SOME GENERALIZATIONS

Since more than four-fifths of the high school science teachers in Ohio were graduated from colleges or universities operating within the state, the current status of science education reflects the quality of teacher education provided by these institutions. Ninety-four per cent of the teachers were fully certified to teach science. Too many instances, however, were found where an instructor had a fine background in one subject area but was teaching in another where he had little or no preparation.

Two-thirds of the science instructors had been on their current jobs for five years or less and one-third had just completed the first year. Schools having enrollments of 500 or more retained their science teachers for a longer period of time than their smaller counterparts. In order to make science teaching attractive to both the experienced teacher and prospective college graduate thoroughly qualified in science, it is necessary for high school administrators to be realistic in making assignments. This involves not only class size, number of preparations per day, free periods for counseling and guidance and preparation for demonstrations and laboratory work, but the elimination of extra duties and assignments unrelated to the teaching of science. Without due consideration to these items, psychological factors influence the individual to look for a situation where he can be happy in his work and develop a feeling of success in the prosecution of the duties associated with the position.

Inasmuch as salary also enters the stability factor, citizens of this nation wanting their children to study science under a specialist, must be willing to pay specialist's salaries. For an inexperienced, thoroughly qualified college graduate, the beginning salary should approximate the $7,000 level. As teaching proficiency is achieved, increments based on merit should raise the annual salary considerably above this figure. The 1957–58 mean salary paid Ohio science teachers with eleven years of experience was $4,900.

General science is pursued by more students than any of the other science courses [2, 3, and 5]. Teachers of this subject should therefore be well prepared because the responsibility for the first effective motivation and guidance is theirs. From this group of students will come most of the prospective biology, chemistry, and physics enrollees.

Data from this investigation revealed that the academic background of many general science teachers was inadequate. The extent of these inadequacies becomes apparent when one realizes that subject matter covered in a seventh, eighth, or ninth grade science class is taken from most of the science areas; and that 20 per cent of the instructors had no college credit in biology, 28 per cent had no chemistry, 39 per cent no physics, 80 per cent no geology, and 94 per cent no astronomy.

The academic background of Ohio science teachers compared favorably with those of Wisconsin [4]. The median number of semester hours of credit earned by the Ohio instructors was: biology teachers, 33 in all areas of science and 24 in biology; chemistry teachers, 48 in science and 19 in chemistry; and physics teachers, 47 and 13 respectively. Corresponding figures for Wisconsin were: biology teachers, 41 in all areas of science and 20.5 in biology; chemistry teachers, 44 in science and 18.5 in chemistry; and physics teachers, 42 and 13.5 respectively.

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SCIENCE AND ITS ROLE IN A LIBERAL-ARTS COLLEGE IN THE ATOMIC AGE *

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INTRODUCTION

We are living in an age of science and technology. This age began about 150 years ago, shortly after the Industrial Revolution in England and has proceeded with great rapidity ever since [1]. With its marvelous methodology, laws, techniques, gadgets and machines, our modes of life in society have changed and have practically brought the nations of the world into a single community.

In viewing the contributions of this age, one can recognize four periods of development. The first is the inventive—which gave rise to many inventions; the second is the mechanical—which made possible the accomplishment by machine of work that man could not do by hand; the third is the electrical—characterized by the production, transformation and conduction of electrical energy and power; and the fourth the atomic—production and use of the energy in the nucleus of the atom. The latter period is the baby of them all, born only nine years ago. All of these periods are the brain children of the liberal-arts colleges and universities of America and other nations of the world.

It is interesting for one to speculate on science and its role in the liberal-arts college in the atomic age. But before one attempts such a venture, it is well to take a panoramic view into the background, aims and progress of liberal education and science, in order to compare and evaluate the present achievements with those of the past.

BRIEF HISTORICAL BACKGROUND OF THE LIBERAL ARTS COLLEGE

The idea of the liberal-arts college is very old, its heritage rich, and purpose noble. Its contributions through the annals of human history have been vital to sound, basic thinking and understanding [2]. As one looks back in retrospect the role and influence of the liberal-arts college stands out crystal clear in our cultural progress. The purpose of the liberal-arts college was to expose one to literature, art, humanities, and science in order that one might acquire a general knowledge and appreciation of life and life's problems and how best to solve them.

Liberal education dates back to the Greeks. Socrates, (470–399 B.C.), the Greek philosopher, started a school of thought in Athens which greatly influenced the period in which he lived. He developed introspectionism and a method of seeking axiomatic truth. He believed that education helped one to better understand oneself. Thus, Socrates' famous phrases that "one should know thyself" and that "one should define one's terms" are as challenging and vital to liberal education today as they were yesterday. The "Socratic method" or questioning and answer recitation method used in education today was given to us by Socrates. Plato (427–347 B.C.), a student of Socrates, founded a school called Plato's Academy, an institute of philosophy and scientific research [3].

The Aristotlean school, called the Lyceum, is another early example of liberal education. Aristotle, (384–322), scientist and philosopher, was a student of Plato's, and like his predecessors, conducted a school where people might seek the truth. His Lyceum was developed more along the lines of the "Socratic method or school;" that is, analyzing, classifying and defining objects in our external and internal environment. One of Aristotle's students

* Founder's Day Address, delivered February 24, 1954 at Wilberforce University, Wilberforce, Ohio.

was Alexander the Great, who conquered Persia. On his march through unknown Greece, he collected many plants and animals and sent them back to his beloved teacher for study. Aristotle and his students classified and made original observations on a wide variety of plants and animals from various sections of the world, ranging from the frog to the goat. He and his students did much to advance the scientific method and the biological sciences. Alexander the Great later established the famous Library and Museum of Alexander, Egypt, a center of learning similar to our present day liberal-arts college or university.

After the Greek and Roman civilizations, there was a dearth in liberal thinking which lasted for 1000 years. This period is called the "Middle Ages." During this era, study and learning was confined to the monasteries and Christian centers where the emphasis was spiritual rather than material. However, during this age of faith and honor, learning and education was not entirely forgotten.

The period that followed the "Middle-Ages" was called the Renaissance, an era of revival in learning and new interest in education. This rebirth or awakening strengthened by the development of the printing press, had a tremendous influence on the development of education in Europe. During the Renaissance there was a rediscovery of ancient learning of Greece and Rome and the development of many new ideas and new areas. The revival of education and liberal thinking came first in Italy. In 1348 a University was established in Florence, Italy, for the promotion of the new learning. From here this movement spread northward over Europe and the British Isles. One of the chief exponents of this period in Europe was Desiderius Erasmus, (1466–1536) whose work in education in England at St. Paul's school is responsible for the humanistic pattern in education. He wrote a book, "On the Right Method of Instruction," in which he emphasized the study of classical literature for a better understanding of the pursuits and activities proper to mankind; and that one should study all subjects dealing with man as a human personality.

This concept of education greatly influenced the development of education in America [4]. In both the Virginia and New England Colonies, there were persons from England seeking a place where they could have freedom of thought and worship. In Virginia, Williams and Mary College was attempted in 1603 under the auspices of the Anglican Church, but a royal charter was not granted until 1693. In 1636, the general court of Massachusetts voted 400 pounds for a college to educate the English in "knowledge and Godliness." Two years later, in 1638, Reverend John Harvard died. He left a large sum of money and his library to the college which was named in his honor, Harvard College. Harvard College was the first liberal-arts college established in America, and for over a half a century was the only center of learning in America. Many of the liberal thinkers and clergymen were connected with Harvard. Two degrees were offered, a Bachelor of Arts and Master of Arts. The requirements for the former was the ability to read the Old Testaments in the original and to translate them into Latin; the latter necessitated seven years of study. In 1718, Eli Yale, a clergyman, founded a school in Connecticut that was named in his honor, Yale College. The program of this college was to further liberalism and liberal thinking. In 1746, Princeton College was founded and supported by the Presbyterians, and later Kings College (1754) (now Columbia University), Dartmouth College (1709), Brown College (1764) in Rhode Island, and the University of Pennsylvania, (1749) were established. It was around this time that so many liberal-arts colleges were established. The impulse to found them, with the exception of the University of Pennsylvania, came from the Church. It was a similar impulse and incentive that gave birth to Morehouse

College, Fisk, Atlanta, Howard and Wilberforce Universities.

It is appropriate and befitting at this time that we pause, re-think and re-evaluate the contributions made to the world by the founders of Wilberforce University and the Church. Dr. Daniel Payne, clergyman, philosopher, writer and scientist, along with his associates, established Wilberforce in 1856 where men might study the great truths of the past and acquire knowledge of the mind, soul, body and the natural environment. This philosophy of education has some desirable features. When implimented by well-trained consecrated teachers, it will serve to lift the veil of confusion, and aid in the solution of our social, economic and political problems today. Wilberforce is ideally situated and has a noteworthy history [5]. It has for a century given to the nation and the world men and women who stand high in their various vocations and communities. During the early days education was scattered and fragmentary. Nevertheless, it marked the beginning of our liberal-arts Colleges and Universities.

STATUS QUO OF THE LIBERAL-ARTS COLLEGE

Education is a treasured social institution of all civilized societies, but the purpose of education is different in each society. An educational system finds its guiding principles and ultimate goals in the aims and philosophy of the social order in which it functions [6]. The facts reveal that this is a truism which has prevailed throughout the history of education. The schools of Athens and Sparta were different because the social philosophies of the two cities were different. The former believed that the school was to make good citizens and that the citizens should acquire the culture of which they were a part; whereas, the latter emphasized the state and militarism, an undesirable technique common to Nazism, Communism and Totalitarianism. The Romans patterned their education after the Athenians and emphasized law, order and oratory. During the "Middle Ages," education was focused upon heavenly or spiritual things, whereas, during the Renaissance, it was placed upon the revival of knowledge, human and material values. It is interesting, thus, to note how the patterns of education followed the aims and philosophy of the social order in which they were to function.

In early America the philosophy of life and education in the New England Colony was different from that of the Virginia Colony. In this Colony the emphasis was placed upon the spiritual side of human values; right to worship, think and acquire knowledge of society and the world of which one was a part. In contrast to this view, certain individuals of the Virginia Colony followed an ego-centric philosophy in which aristocracy there was little or no thought of the rights of other members of society. The underlying philosophy of education here was that education was for gentlemen of leisure and how to make them. The economy in this Colony for the most part was based upon a slave system, and obviously the middle class and slaves did not have the time nor right to worship, think, acquire kuowledge and enjoy the material blessings of a society and world in which they were a very vital part. The doctrine of education for the chosen few did not please Thomas Jefferson, (1743–1826), a native Virginian, and he differed sharply with his contemporaries. He was a liberal and after reading Jean Jacques Rosseau's book, "Le Sociale Contract," developed a greater respect for the rights of the common man. In 1776, he wrote the Declaration of Independence, in which he stated that all men were created free and equal and entitled to liberty and the pursuit of happiness. Shortly thereafter he recognized that there was no equality in education and no general freedom of educational opportunities in the new nation.

Jefferson also believed that education was essential in a democracy and while a member of the Virginia Legislature submitted a bill in 1779 for free public education in the state. This bill was called "A Bill for the More General Diffusion of Knowledge," the first proposal in America to establish a state system of public education. The plantation aristocracy rejected Jefferson's plan and by so doing brought about a differential in American education which still prevails and still underminds the very moral fiber of our democratic way of life.

The status quo of the liberal-arts college and American education today is characterized by the use of various techniques to retain this traditional differential. There exists now in certain sections of the nation an inequitable distribution of financial support to public education; there is also inadequate physical facilities as compared with other schools in a given area. In higher education, this differential has been made evident in the different standards of evaluation in accreditation of some of our schools. Also, there are those who feel that there is a lack of academic freedom, which underminds the very foundation of education. In some of our institutions of higher learning, limited opportunity to do adequate graduate work in various fields of education seems to be the order of the day [7]. According to Dr. Zook, President of the American Council on Education, "there are, however, other barriers which we can do something about, those which are racial and economic. There are in this country today millions of persons who, because they have black skins are denied opportunities in higher education which is available to people of the white race" [8]. If this statement be true, then some of our liberal-arts colleges and universities, serve more as social control rather than as democratic agencies, as laid down by Thomas Jefferson and some of our eminent leaders in American education [9]. We live in a democracy and our education should be keyed or undergirded to the democratic idea that guides our life pattern. If we are to have equal freedom and equal rights, we must develop a democratic system of education for all Americans, regardless of sex, race, religious faith and economic status.

TRANSITIONS IN THE LIBERAL-ARTS COLLEGES AND UNIVERSITIES

Despite the inertia of some individuals to change an outworn traditional educational policy and practice, and descrepancies in our educational system in the past, some progress has been made and there are signs now of a transition or change in some liberal-arts colleges and universities. In the southern section of our country, liberal-minded educators are beginning to admit all of its citizens to their colleges and universities. Recently, a very distinguished Negro educator was placed on the Board of Education of Atlanta, Georgia, by both Negro and white voters. The United States Department of Defense has just issued an order to abolish separate schools on all of its Army bases. In this same connection, the United States Supreme Court is now studying the possibilities of abolishing separate schools for its citizens throughout the nation.* There are other examples relative to this change which could be cited, but the above will serve to indicate that America is giving some real meaning to the professed ideals of democracy and that all of its citizens are becoming articulate in the American social order. This is the way it should be, the American way, the right way and just way. Discrimination not only in education, but on all levels of society, is an evil and cannot be justified by a nation that claims to be democratic and Christian.

THE IMPACT OF SCIENCE ON EDUCATION

We are living in an age of science and technology which has had a tremendous impact upon education. This era started 150 years ago shortly after the industrial

* Incidentally, since this paper was written, the United States Supreme Court, on May 17, 1954, declared segregation in the Public Schools unconstitutional and many of the Southern States have begun desegregation.

revolution (1746) in England. Since this time men have used the scientific method and discovered laws, methods, and principles; invented gadgets and machines; and have formulated and compiled scientific information of all descriptions. One of the great problems produced by this age is the proper use of these discoveries, inventions and scientific information to the greatest advantage for the largest number of people. One of the major roles of the liberal-arts colleges and universities is to teach us how to properly use the instruments of science to the benefits of all the people and prevent their mis-use.

The ingenious mind of man has developed the natural sciences and their application in technology and engineering at a very rapid pace. Science has created a world in which the mechanical advantage and efficiency of the vehicles of transportation has reduced time considerably. One may take an airplane in New York or Ohio and within a few hours be in California or Paris; in America, one can talk to a friend in Paris while he listens to an opera in Berlin, Germany, or watch the Coronation of the Queen of England; by his skilled hand the chemist can take his retort, crucibles, balance and test tubes and give us clothes to wear and food to eat; his vitamin and synthetic foods may sustain life indefinitely; and by the so called magic sulphur drugs and biotics and anti-biotics, he may prolong our life expectancy upon this earth. Science has aided in bringing the nations of the world into a closer range of contact and creating a one world community. In this one world, science requires the vigilance of all nations. It also demands that the dominant nations use their scientific skill and "know-how" to maintain the peace of this and future generations. Scientists are becoming more and more conscious of their social responsibilities. The day is passing rapidly when scientists are regarded only as stoop-shouldered, bearded old men in torn, dirty-white coats who have shut themselves off from the world and have no concern with the situations and conditions of mankind. They have begun to realize more clearly the tremendous human implications of the forces which their investigations have on society and the world. Scientists are eager that their science shall work for human welfare and human betterment, and our institutions of learning should give counter emphasis to this end.

The scientist desires to make this world a better place in which to live. With this objective in mind, he has selected special areas of science in which to do concentrative work. Each village has had its butcher and baker and candle-stick maker, specialists in their trades who supply others with their products. The scientific age has greatly increased this specialization. It is not enough now to be a chemist or engineer; one becomes an organic chemist, specializing on long chains, esters or carbohydrates, or an electrical engineer specializing on echoes of short electric waves. The world needs this special knowledge and were it not for technology, by which the work of each person is multiplied through the use of power machines and methods of mass production, the work of many highly specialized individuals could not be realized. Were it not for science, which has made possible such developments as the steam engine, airplane and other advances in transportation, the radio and television, there would be no markets to absorb technology's mass production.

The specialization of science and the mass production of technology have built a society of unparalleled richness and strength. A feature of this modern society is that its strength depends to a large degree upon the cooperation of its members. Unfortunately, we have not learned the lesson that the world built by science and technology is only possible through whole-hearted, widespread and unselfish cooperation. This is a basic lesson that the liberal-arts colleges and universities may teach in this age of rapid scientific progress.

EDUCATION IN THE ATOMIC AGE

Specialization in the age of science and technology has also given man an urge and zeal to use his special knowledge and skills to explore the unknown infinitesimal unit of matter called the atom. However, the idea of the atom is not a new one, because since time immemorial man has been interested in understanding the complex make up of matter [10]. The empirical concept of matter and the atom dates back to its principal advocates, the two Greek scholars: Democrats and Leucippus.

The nature and meaning of the atom did not begin to reveal itself until the early part of the 19th century, from the investigations of Dalton, Avogadro, Gilbert, Ampere, Volta and Faraday. However, during the early part of the 20th century the atom was under constant study and its nature more clearly and accurately expressed in the work of Arrhenius, Swedish chemist and Nobel Prize winner of 1903; the famed Monsieur and Madame Curie who discovered radium in 1898, which gave new hope and knowledge about atomic energy; and Becquerel in 1806 and Roentgen in 1895 made substantial contributions to radio-activity.

During World War II, Niel Bohr, Danish physicist, and the American scientist, Irving Langmuir, two Nobel Prize winners, studied the structure of the atom and added their portion of reliable knowledge to the whole body which is of use to us today. Further efforts to discover the secrets underlying atomic energy were also made by Albert Einstein, Harold C. Urey, Arthur Compton, the late Robert A. Millikan, Erico Fermi and a host of others lesser known. The latter scientists organized research groups or teams composed of the best scientific skill in America. Each major or senior scientist directed certain phases of investigation of each group on the atom under federal supervision and secrecy. It is interesting to note that some Negro scientists were members of these research groups and lent their talents and skills in the final fashioning of the atomic bomb [11].

For the most part, the scientists and scientific facilities of our liberal-arts colleges and universities were used to study the practical possibilities of the atom. By using the chain reaction discovered by O. Hahn in Berlin, Germany, atomic energy was released which formed what we know today as the most deadly instrument ever produced in the history of scientific investigation—the atomic bomb, the first of which exploded in Alamogardo, New Mexico, on July 16, 1945. It was this day which formally inaugurated the atomic age in which we are now living.

This wartime research has not only produced the atomic bomb, but magnetic mines, radar, the helicopter and a variety of new weapons developed by scientists. Men of science worked long hours and hard to make the tool of war which suddenly brought to a close World War II when six men in a B-29 airplane flew over Japan on August 6, 1945 and dropped the atomic bomb on Hiroshima and Nagasaki. This one atomic bomb had a destructive force undreamed of and killed over 75,000 men, women and children.

The writer feels that the above tragedy is flagrant mis-use of science and defeats the very purposes and principles upon which civilization itself is based.

SCIENCE AND MAN'S STRUGGLE FOR POWER

Man has begun to feel that science is power and might. This over emphasis of science also has allowed man to develop his natural or material resources far beyond his moral or human resources. In this age of science and technocracy man should realize that in this human equation of life, aside from his natural or material problems, there are his artistic, social and moral problems to be solved and human resources to be developed. One should forever realize "that man cannot live by bread alone." There are other aspects of his nature that transcend a fine car, airplane, radio, television, an atomic bomb, or even science itself; he has a will—an ethical obligation to himself and society.

The writer, in a Founder's Day Observance address, February 12, 1946 at Livingstone College, Salisbury, N. C., made the following statement, "Science is not static, but dynamic. By the same process that the atomic bomb was started by Germans and completed by Americans, so may it be improved by other nations" [12]. That statement was made nine years ago and we know today that there are other nations that have the atomic bomb and are improving it. Science and its role in the liberal-arts college in the atomic age must be more of a humanizing force and work for the greater good of society; it must strive to awaken and quicken the inherent goodness of man, and bring about the proper balance between the natural and the social sciences. Because, today, education finds itself in a world where nations are struggling for power through the use of science and technology, with little regard for how it effects society.

CONCLUSION

In this atomic age when man unlooses the fury of the universe against himself, in this ever shrinking planet on which mountains have shrunk to molehills and oceans into mere trickles of water, science will be forced to set up certain standards of behavior to guide man in finding an understanding of himself. In this "high noon" of scientific progress, we must not fail to consider that science may be the servant of mankind or may be his destruction. The fate of the world from here on is a common fate. Never before has man had so challenging a necessity to master his own destiny. With the new interpretations for the maintenance of a democratic society, with science, the new tools of technology, and the new views of man's place in nature that science has opened, we need to ascertain more clearly how we may shape the world to come. To this end, mankind and civilization must put into practice devotion to a high code of moral values in order that atomic energy may be used in the world as a force for good. Steadfast reason and brotherly love must supplant hatred and blind brute force; the will to live and to share must substitute for misplaced nationalism, discrimination and greed for possession; a belief in and practice of the principles of Jesus Christ must triumph over bigotry and dogma. To the liberal-arts college falls the task of helping to make these desirable and essential goals an unequivocal reality.

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HOW CAN THE CURRICULUM FOR HIGH SCHOOL BIOLOGICAL SCIENCE TEACHERS BE IMPROVED?

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THERE has been considerable discussion in the public press, by scientists, educators and government officials about the quality of science teaching. Much of the discussion has emphasized the need for higher teachers' salaries, additional classrooms and equipment, and other financial support.

Equally important, however, is an appraisal of the type of preparation secured by science teachers in our colleges and universities. The Biological Sciences have received less attention than the other sciences as they are considered less essential to the Defense Program than the physical sciences and mathematics.

This paper proposes, however, to consider only one aspect of the preparation of high school biology teachers: the curriculum. Other aspects of their preparation, course content, the quality of instruction, etc., although equally important, will be considered only in relation to the curriculum.

Several regional and national conferences have considered problems related to the biology curriculum and the preparation of high school biology teachers. Breukleman, et al. (1955) summarized the recommendations of the Southeastern Conference on Biology Teaching. They concluded that the curriculum should include a minimum of 24 semester hours in the biological sciences, including both botany and zoology and field studies, one year of chemistry, one year of physics, one-half year of earth science, and one year of mathematics. Mallinson (1957) in his summary of the Midwest Regional Conference on Science and Mathematics Teacher Education listed the following recommendations for the biological sciences: that there be a balance between botany and zoology; that the principle of selective admissions to the teacher preparation program be adopted; that most physical education courses not be recognized as the equivalent of courses in the biological sciences (coaches are often able to meet state certification requirements with a minimum of preparation in biology); and that biology teachers have "some" work in the physical sciences. Johnson et al. (1958) listed the following recommendations in a report on the proceedings of a conference sponsored by the National Academy of Sciences: that studies in the sciences for secondary school biology teachers should comprise not less than one-half of the undergraduate program; that one-fourth of the total undergraduate work be in the biological sciences; and one-fourth in the physical and earth sciences. Also, that it should be a "core program," and no more than 10 per cent of the work should be in a professional specialty elected by the student. They recommended that prospective biology teachers take as a minimum, two years of chemistry, one year of physics, and one year of mathematics; also field biology and methods of teaching biology.

Baker and Brooks (1957) made a survey of the preparation of high school teachers in Kansas in 1955–56. Their data shows that of 539 biology teachers, 53 per cent had no credit in general biology, 42 per cent had no botany, 34 per cent had no zoology, 87 per cent had no field biology, 32 per cent had no chemistry, and 42 per cent had no physics, and that 7.6 per cent of all biology teachers had no academic preparation in general biology, botany or zoology. They recommended that biology teachers should have preparation in the basic courses in botany, zoology and field biology, and that courses in health, foods, hygiene, nutrition, and farm crops are of secondary importance and should not satisfy the requirements for science teaching. Nelson (1956) surveyed the preparation of 63 high school biology teachers in Illinois. Their preparation in science ranged from 12 to 95.3 semester hours with a median of 47 semester hours. Fourteen of the 63 had no chemistry, 23 had no physics, 11 had no chemistry or physics, and 18 had less than a minor in biology. Nelson also indicated that the administrators in his sample ranked first the following statements appearing in the survey: "Training (of science teachers) spread over several science subject matter fields (physics, chemistry, biology, earth science, etc.) and in addition, intensive training in one field of science." They ranked second, "Sufficient training in several science fields . . . so that the teachers can give instruction in more than one science." Pella (1958) made a survey of the preparation of 367 biology teachers in Wisconsin. Only 2.8 per cent had no preparation in biology, 40.6 per cent had no physics, 20.2 per cent had no chemistry, 39.2 per cent had no earth science, and 24.6 per cent had no mathematics. The full-time biology teachers had more preparation in the sciences than did the part-time teachers. Crall and Myers (1958) made a survey of the requirements for the Master's degree for high school biology teaching. They recommended that the curricula for biology teachers be different from that for an administrator, that the graduate curriculum should aim toward the preparation of a "master teacher" and that it help the teacher to learn *what* to teach in addition to helping him learn *how* to teach.

NATURE OF THE PROBLEM

The study was begun early in 1958. It surveyed two problems by means of questionnaires: (1) What are the requirements in the sciences and foreign languages in the curricula for high school biology teachers in certain teachers colleges, state colleges and smaller state universities? and (2) What are the best teaching combinations with biology in terms of vacancies reported at the Placement Bureaus of these schools?

Letters explaining the purpose of the survey were sent to the heads of the departments responsible for the preparation of biology teachers in 90 colleges and universities from New York to California. A questionnaire on a posted, self-addressed post card was enclosed which made it convenient to prepare replies. A similar letter and post card were also sent to Placement Bureaus of the same schools.

Most of the schools contacted were either state teachers' colleges or state colleges whose main function is teachers preparation. Replies were received from 64 schools concerning curriculum requirements. Of these, 7 stated that they did not prepare biology teachers. Data obtained from 28 state colleges and universities and 29 state teachers' colleges were used in preparing this report.

Curriculum Requirements

The results obtained from the questionnaires are tabulated in Table I.

TABLE I

CURRICULUM REQUIREMENTS FOR A MAJOR IN BIOLOGY FOR HIGH SCHOOL BIOLOGY TEACHERS

(57 Colleges and Universities)

Subjects	No Requirements (No. of Schools)	Average Semester Hours in Schools Requiring These Courses
Botany	10	7.3
Zoology	8	7.8
Total in biological sciences	0	26.8
Chemistry	23	7.6
Physics	32	6.6
Geology	24	5.6
Mathematics	41	4.6
Foreign language	51	7.3
Mathematics, chemistry, and physics	20	—

These data indicate that there are wide variations in the curricula for high school biology teachers in the 57 colleges and universities. More than one-third do not require chemistry, over one-half do not require any physics, and comparatively few require mathematics or foreign language. Ten have no definite requirements in botany and eight do not require zoology. *Over a third do not require any chemistry, physics, or mathematics.* Nearly half do not require any geology (or earth science).

These data indicate that students preparing to become high school biology teachers in a large proportion of the schools included in this sample are *not required* to obtain a broad background in the physical sciences or mathematics, although a number of schools indicated that they recommend courses in these areas.

Teaching Combinations

A smaller response was obtained from the Placement Bureaus concerning the best teaching combinations with biology, and only 40 replies were received from the 90 schools contacted, and of these, 13 did not prepare biology teachers. It may indicate that the data requested was not readily available or that some schools do not have active Placement Bureaus. Analysis of the questionnaires was difficult because some schools did not give complete information, and some gave estimates. The results which can be considered only approximations, are shown in Table II.

These data indicate that the best teaching combinations based on data obtained from vacancies reported to Placement Bureaus, are biology alone, or biology combined with general science, physical science, coaching and mathematics. Over 60 per cent of the calls were for biology alone or in combination with general science or physical science. Combinations with social science, English, driver training and home economics and other courses not listed here are called for much less and a number of schools have no calls for them at all. The data also indicates that high school administrators frequently seek teachers who can coach. Perhaps this has become traditional.

TABLE II

Teaching Combinations With Biology That Are Most in Demand as Indicated by Vacancies Reported to Placement Bureaus

(27 Colleges and Universities)

Subjects	Average (Per Cent)	No Calls (No. of Schools)
Biology alone	21	5
Biology and general science	18	1
Biology and physical science	23	0
Biology and girl's P. E.	3	6
Biology and coaching	12	3
Biology and mathematics	7	3
Biology and social science	4	1
Biology and driver training	3	5
Biology and English	2	5
Biology and home economics	1	7

DISCUSSION AND RECOMMENDATIONS

On the basis of the results of the survey and in the interest of preparing teachers who are well prepared to teach biology in high schools, we make the following recommendations concerning the curricula for high school biology teachers:

1. *The curriculum should provide for a sufficient number of required specified courses in biological science.* In order to be well qualified to teach biological science the teacher needs as much preparation, perhaps more, than for the other sciences. It should be emphasized that not "just" anyone can teach biology or that a few courses in health, physical education, and agriculture provide adequate preparation. Examination of many recent high school biology textbooks will show the breadth of preparation needed. Memorizing the text materials will not provide the background needed for the teacher to interpret, demonstrate and explain fundamental biological concepts to the average high school student of today. Such preparation is also needed if the teacher is to help the superior student.

The curriculum should also include at least one course in field biology which would help him to lead field trips, to identify common animals and plants. It should include some ecology which is essential for explaining problems related to conservation.

Biologists should promote a public relations program that will tend to off set the popular notion that a course in biology consists largely of dissecting frogs and pickled plants (or if it does, it is not a modern course), and that biology is a vital dynamic experimental science in which all the available tools of the physical sciences and mathematics are used. Biologists in the past have been too dependent upon the discoveries of the chemists and physicists to forge ahead on their own.

As long as biology is taught in many schools by coaches and others who have "minors" in biology consisting largely of courses in hygiene, kinesiology, and agriculture, non-laboratory survey courses, etc., biology cannot be expected to receive the respect and the interest from students that it deserves. The course content of high school biology courses should be carefully evaluated and the minimum laboratory facilities and equipment required should be listed. If biology can be taught in an ordinary classroom with a demonstration table and ordinary desks, a few aquaria and several broken-down microscopes, it cannot be expected to be considered as a science course—it becomes at best, a course in natural philosophy!

State departments of education and regional accrediting agencies should be asked to reconsider the type of preparation recommended for biology teachers and the minimum physical facilities and equipment needed in an accredited high school. This might require school administrators to look for well prepared biology teachers and to consider the science laboratory as important as the gymnasium, and science equipment as important as that for football, basketball and the marching band.

2. *The curriculum should be balanced and provide for preparation in both botany and zoology.* The beginning courses and the rest of the curriculum should include both botany and zoology. Botanists frequently complain that biology teachers have little or no background in the plant sciences. Examination of the catalogs of some colleges preparing teachers, especially the smaller ones, list none or only several courses in botany. We conclude that graduates of some colleges obtain no preparation in botany. Perhaps the biology departments of some smaller colleges emphasize pre-medical preparation and lack teachers well prepared in botany.

Wallen (1956) reported that one of the proposals of the Science Teaching Improvement Program of the A.A.A.S. is to assist colleges and universities and other institutions of higher learning in getting their science and mathematic departments to agree in their acceptance of teacher education as a major responsibility.

3. *Provision should be made for electives and to allow the student to concentrate in certain areas.* The curriculum should be planned so that students can take advanced courses in certain areas so that they can add depth to their preparation. Advanced courses in both botany and zoology should be available.

4. *The curriculum should include required courses in both chemistry and physics.* As Heller (1958) has so aptly stated, "The scientist of our new revolutionary era can no longer afford the 'tunnel vision' of the specialist of yesteryear. He must tear down the artificial barriers which used to prevent him from looking beyond his specialty into other fields."

At least one year of chemistry and physics should be required. In order to teach a modern course in biological science and to place it in its proper relation to the other sciences a background in the physical sciences is essential. Such topics as photosynthesis, metabolism, respiration, diffusion, digestion, the effects and use of radioisotopes, etc., can only be given adequate treatment by teachers who have had courses in the physical sciences. Such preparation will be helpful in setting up laboratory demonstrations, preparing chemical solutions, constructing apparatus, helping gifted students, and supervising student projects for science fairs. A biology teacher today without preparation in the physical sciences is hopelessly handicapped! Many colleges and universities preparing high school biology teachers should plan to revise their curricula and have definite requirements in the physical sciences.

5. *The curriculum should include courses in mathematics and earth science.* Biology is becoming increasingly dependent upon mathematics, particularly biometry, as an aid in the interpretation of scientific data. A background in mathematics is essential.

Earth science, particularly geology and meteorology, are important in ecology and conservation. They are especially important for the general science teacher.

6. *The curriculum should be organized to permit the teacher to take graduate work so that he can earn an advanced degree in biological science.* The curriculum should have an "open end" and not be terminal. It should be organized so that the teacher can continue with graduate work and as a minimum, earn a Master's degree in the subject matter area that he teaches. Because of a lack of adequate preparation in science and mathematics he may be forced to earn a Master's degree in education. Most experienced science teachers need additional preparation in the subject matter that they teach rather than in *how* to teach.

Just as the demand for high school science teachers has increased, so has the demand increased for teachers in the colleges and universities. The Ph.D. is usually considered as essential for the college or university teacher. Data prepared by Maul (1955–57) shows that there has been a drop from 31.4 per cent in 1953–54 to 23.5 per cent in 1956–57 of new full-time college teachers who held the earned doctorate. For teacher's colleges the percentage dropped to 15.7 per cent. New college teachers holding less than the Master's degree increased from 18.2 per cent in 1953–54 to 23.1 per cent in 1956–57. Well qualified high school teachers who have well organized preparation as undergraduates and who earn the Master's degree in the biology sciences should be a potential source of college and university teachers. (See also, Myers and Crall, 1958.)

7. *The curriculum should be planned so that the student will qualify for the best available positions.* The curriculum and counselling program should be in harmony with the current calls for teachers in the area served. The beginning teacher frequently obtains his first position in a small high school and is often expected to teach general science. The data in Table II obtained from the Placement Bureaus of 27 colleges shows that approximately 18 per cent of the calls are for biology teachers qualified to teach general science. In the authors' institution nearly 50 per cent of the vacancies reported are in combination with general science, and fewer than 5 per cent of the vacancies reported are in combination with English, social science, home economics, driver training and music. Majors in the biological sciences are strongly advised to elect minors in the physical sciences as this is one of the most frequent combinations requested with biology. This is not difficult as one year of chemistry and one year of physics are required in the curriculum for biology majors.

Another consideration should be for those who for various reasons do not qualify as competent and successful teachers. A strong background in science may enable them to obtain a good position in industry or government service.

However, the authors' have heard it suggested that if biology teachers obtain broad preparation in science they may be offered higher paying positions in industry or government service and thus be lost to the teaching profession. This implies that teachers should be prepared so that they have no choice but to teach. It should be emphasized that science teachers are not missionaries and that they deserve a remuneration that will make teaching as financially attractive as other professions requiring equivalent preparation. If sufficient numbers of adequately prepared science teachers are available we should be able to locate and prepare the technicians and scientists that we need to compete successfully with the Soviet Union.

Biologists are disturbed that the government does not offer them salaries equivalent to those of chemists, physicists, and engineers. Actually a considerable number of physical scientists are employed in laboratories to do biological research, but largely because biologists often do not have adequate preparation in the physical sciences and mathematics. A biologist with sufficient preparation in chemistry can receive the higher increments and probably would replace chemists working on biological problems. A colleague has suggested that a research organization finds it easier for a chemist to learn enough biology to do biological research than it is for a biologist to learn enough chemistry!

SUMMARY AND RECOMMENDATIONS

1. Questionnaires were sent to 90 colleges and universities, mostly teachers' colleges and state colleges, to determine their curriculum requirements for the preparation of high school biology teachers. This included requirements in botany, zoology, total biological sciences, chemistry, physics, geology, mathematics, and foreign language.

2. Replies were received from 64 colleges and universities. Seven did not prepare biology teachers.

3. The replies from the 57 schools included in the sample indicated that more than one-third (20) do not require any chemistry, physics or mathematics, over one-third (23) do not require any chemistry, that over one-half (32) do not require any physics, and about two-thirds (41) do not require any mathematics. Fifty-one of the 57 do not require any foreign language.

4. Questionnaires were also sent to the Placement Bureaus of the same 90 colleges and universities.

5. Replies were received from 40 colleges and universities. Thirteen did not prepare biology teachers.

6. The replies indicated that most vacancies reported were for teachers prepared to teach biology alone (21 per cent), in combination with general science (18 per cent), physical science (28 per cent), and coaching. Over 60 per cent of the vacancies were for biology alone or in combination with general science and physical science.

7. It is recommended that the curriculum for teachers of biological science be organized to require:

a. Broad preparation in the biological sciences, including both botany and zoology, and field biology.

b. Areas of concentration (depth in the biological science).

c. One year of physics and one year of chemistry.

d. Mathematics and earth science.

e. That the curriculum be organized so that the student may take graduate work and earn a Master's degree in a biological science (or at least a major if the Master's degree is in Education).

f. That the curriculum be organized so that the student will qualify for the teaching positions for which there is the greatest demand.

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A LABORATORY STUDY IN RADIOACTIVITY DESIGNED TO EXAMINE REACTION TO UNEXPECTED EXPERIMENTAL RESULTS *

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LABORATORY studies in science are usually concerned simply with providing problem-solving situations in subject matter content. Rarely does the structuring of a study provide means for analyzing the thought processes or mental reactions. In this study, students encounter experimental results which are completely contrary to their expectations. It is at this crucial point that the emphasis in the study is directed. The series of statements following the unexpected turn of events provides interesting clues to the complex manner in which the mind appears to work in such situations. The author was particularly interested in discovering whether third term Natural Science students at Michigan State University reacted in much the same way as scientists might react. If some correlation was found, it could conceivably be interpreted as an indication that these students had acquired some of the habits of scientific thinking and problem solving in addition to any they may have already possessed.

Lawson [1] has suggested that a scientist begins an investigation with some form of motivation and with a specific goal or problem and that he then selects a hypothesis as a possible solution of the problem. Furthermore, he states that if the actual results differ noticeably from the expected results several things may happen. First, the investigator may explain away the differences by means of a secondary hypothesis, second, he may be stimulated to doubt the accuracy of his observations, or if upon repeating them, he finds no errors, he may doubt the original hypothesis and seek a substitute.

In this particular study, students were confronted with a situation comparable to that which Becquerel encountered when he accidentally discovered radioactivity. Under these circumstances students could acquire some insight into the way their thinking shifts back and forth from hypotheses based on limited facts and past experiences to new and sometimes inconsistent facts. Such an historical approach likewise brings to light the manner in which conceptual schemes emerge as new facts are resolved.

Because only a portion of the laboratory study pertains to the situation described in this paper, all irrelevant materials have been delected.

THE DISCOVERY OF BECQUEREL RAYS—STUDY 17

After the discovery of X-rays a most stimulating idea was suggested in relation to the fluorescent properties of the discharge tube. Poincare, Becquerel, and others had observed that X-rays appeared to originate and proceed from that part of the discharge tube that glowed or fluoresced most strongly. Becquerel reasoned that if the fluorescent spot on the tube was the source of the X-rays, then it might be that other materials that fluoresced would likewise produce X-rays. Becquerel was interested in testing this hypothesis especially since he had previously studied the phenomenon of fluorescence and had in his possession just the materials that would serve for an experiment. He tried a number of substances and at first his results were negative. While these preliminary tests were disappointing he was not discouraged. On trying a certain compound of high atomic weight be obtained some surprising results. In the following experiment which is comparable to Becquerel's work we shall see where his hypothesis led.

PROBLEM I. TO STUDY THE RELATION OF FLUORESCENCE TO X-RAYS

Examine the samples of fluorescent salts under an ultra violet light lamp. Samples

* Contribution No. 93 from the Department of Natural Science, Michigan State University.

A and B are identical. Sample C differs in chemical composition from A and B.

Do the three samples fluoresce or glow in ultra violet light? ———. This glowing is similar to that produced by an X-ray tube on fluorescent material.

In order to make materials fluoresce or glow visibly they must be exposed to radiant energy of the proper wave length such as ultraviolet radiation.

PROCEDURE

Three strips of scotch tape, impregnated separately with the luminescent salts A, B, and C, were taped to the outside of a black paper envelope containing X-ray film. Sample B was separately covered with dark paper so that it was not directly exposed to the ultraviolet light. The envelope was then exposed to ultraviolet light in a cabinet for two days and the film was processed. It will be accepted as a fact that ultraviolet light does not penetrate the black envelopes used.

Before you look at the negative in the envelope refer to Table I. The first line is filled in. Using a plus sign if the image is expected and a minus sign if none is expected, fill in the second line as you predict the negative will appear. The remainder of the table can be filled in after the negative is seen.

Note to reader: Nearly 100 per cent of the students filled in the expected results as shown in this table.

TABLE I

RESULTS AND INTERPRETATION OF LUMINISCENCE

	Sample A	Sample B	Sample C
Exposed to light	+	−	+
Expected results	+	−	+
Actual results	+	+	−

Having completed the table, the students were confronted with the following series of questions. The object was to discover, as far as possible, the kinds of mental reactions which they experienced when the actual results of the experiment differed so markedly from those predicted. The results of the responses of two groups of 50 students each is indicated in the margin opposite each statement.

Place a check in front of those reactions that you experienced. Additional reactions should be listed in the space provided.

50–48 1. You began to search for a new explanation or hypothesis which would explain the new facts.

13–5 2. You remembered your experience with the paddle-wheel experiment and accordingly hesitated to discard the hypothesis.

35–18 3. You wondered if you hadn't accepted a hypothesis simply because it was proposed by a famous scientist.

25–27 4. You were quite ready to consider a new hypothesis because you felt this was proper scientifically.

12–12 5. You felt that the original hypothesis was a very weak one to begin with.

49–38 6. You wanted to re-read the procedure and the hypothesis.

50–49 7. You recognized that a problem existed because of the unexpected results.

46–49 8. You knew that a new system or conceptual scheme would be needed to explain the new facts.

27–38 9. You questioned the validity of the results.

10–9 10. You suspected an error in the mechanics of the experiment.

28–22 11. You began to check your original predictions against those made by other members of the class.

2, 7 12. You immediately rejected the hypothesis without having a new one to replace it.

13. Free responses: (see comments).

HISTORICAL

In science, inconsistent facts are not ignored for long. Sooner or later an attempt is made to arrive at a logical scheme to explain them. In essence this is one of the significant reasons why science is a dynamic enterprise. Facts interact with ideas and systems of ideas. Man is never content when these are out of tune or harmony with each other. This has been true historically and there is no reason to assume that man will change in this respect in the near future.

The high atomic weight material that Becquerel chanced to use in his experiments was a salt of uranium. At first he assumed that the images produced on the film were due to the fluorescence of the salt when exposed to sunlight. On one occasion, because the sun shone only intermittently, he had placed the materials (crystal and film) in a drawer. He anticipated that on developing the plate (film), only a faint image would be found. Instead, there was a very intense silhouette of the crystal on the film. Becquerel then tested this unexpected turn of events again. He found as you did that exposure to light was unnecessary and that the results could not be explained by fluorescence. Thus was radioactivity discovered. It is another notable instance of a significant discovery resulting from the testing of a fallacious hypothesis. This is a point that is often ignored by those who are unfamiliar with the historical development of new ideas.

The history of science is replete with instances where new facts were uncovered by men who themselves were unable on the basis of their own understanding of natural events to suggest an adequate explanation. Invariably, however, someone eventually attempts a solution to the dilemma. Becquerel was unable to explain radioactivity because it was a behavior entirely foreign to his understanding of natural events. By trial and error, i.e., purely empirical methods, he did discover new facts about the properties of radioactive substances by contrasting them with X-rays about which certain facts were known. Beyond this he could not go. He lacked a scheme which would provide him with a means of making predictions which could be tested directly. Obviously he had no idea that these radiations would serve as the basis for a new conceptual scheme that would replace Dalton's solid atoms.

COMMENTS

That the students responded to the unexpected results in the experiment on fluorescence in much the same manner as scientists might, is evident from the data. In response to item "1" and item "8" which is essentially the same, 96.5 per cent of the students indicated they felt that a new hypothesis or conceptual scheme was needed to explain the new facts. Eighty-seven per cent felt the need to re-read the procedure and the hypothesis. That their faith in their original hypothesis was firm is indicated by the fact that 65 per cent doubted the results. This is further confirmed by the fact that only twenty-four per cent felt the hypothesis was weak. Only nine per cent were ready to reject their hypotheses without having a new one to replace it. This means that a large majority were cognizant of the fact that in science, theories are not discarded because of a few inconsistent facts. Among the few responses by the students are the following.

I tried to determine what the controls were and to see if they were satisfactory.

My concern was with the meanings of some of the terms used.

I felt the need to check my observations again.

I recalled a movie we had seen on this incident.

I was almost sure a substance could glow or radiate without activation.

Lawson [2] suggested that in analyzing what scientists do, one of three procedures takes place. (1) Repeat the experiment to confirm or reject the results. (2) Modify ones conceptual scheme to accommodate the new facts. (3) Discard the scheme used previously and replace it, if possible with a better one.

The results of this study seem to confirm the proposition made by Lawson [3] that the BET process operated whenever beliefs were changed. The amount of refinement of an individual's responses to his beliefs depends, at least to a certain degree, on the amount of training in methodology and past experiences. If a course in science is so structured as to bring awareness of the desirable types of responses and an understanding of how science matures, then such a course is designed in the proper direction even if it is at the expense of descriptive content.

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PERSONALITY ASPECTS RELATED TO MISINFORMATION ABOUT SEX AMONG COLLEGE STUDENTS † *

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THE field of misinformation and unfounded beliefs is largely unscientific in origin. It is related to man's ancestry from an anthropological viewpoint and it is related to man's environment from a sociological viewpoint. It has been found that many of the misconceptions and superstitions believed today are similar to those of primitive civilizations—of today, and of long, long ago.‡ Formed out of ignorance, determined largely by fear, these misconceptions are omnipresent—controlling and influencing the lives of all of us.

In the field of misinformation about sex, inadequate adjustment to life situations may result from the basic emotion *fear*; fear of sex, beginning with the fear of heterosexual companionship, symptomatic in immature social adjustment; fear of sex, with the fear of one's physical growth at puberty as evidenced in the development of secondary sexual characteristics, menstruation and seminal emissions; fear of sex, with the fear of cohabitation culminating in the reproductive function in adult life; fear of sex, with the fear of sexual inadequacy symptomatic of certain neuroses, frigidity and impotence.

It is stated by English and Pearson [5] that "the purpose of education is to train the ego in skills that will enable it to deal with the realities of life." From this it follows that one of the responsibilities of an educational system is that of helping individuals to make satisfactory adjustments. Nevertheless there is evidence demonstrating that improper adjustments do occur as the result of misinformation about sex despite the fact that our educational facilities and opportunities have expanded and are being utilized by increasing numbers of people.

To attempt to determine the extent and kind of misconceptions, and to attempt to show how these affect or relate to certain aspects of personality is the goal of this investigation. To stimulate further means of combatting, enlightening and eliminating these fears, taboos and misbeliefs is the hope of this investigator.

THE PROBLEM

The problem of this investigation has been one of the determining the relationship between misinformation about sex manifested in a group of college students and certain social and physical aspects of personality.

Analysis of this problem has been approached through four subsidiary problems, which, taken in sequence, represent a logical order of procedure and summation of the steps involved in the direction, exploration and synthesis of the major problem of this investigation.

The first subsidiary problem was to construct an inventory of beliefs designed to determine misinformation about sex. This problem was resolved by the determination of the items of misinformation about sex, the compilation of a list of misinformation about sex, the evaluation of the list of misinformation about sex and the construction of a final inventory of beliefs.

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* Based on thesis entitled "The Relationship Between Misinformation About Sex Manifested in a Group of College Students and Certain Social and Physical Aspects of Personality" submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, New York University.

‡ It is not possible to include here the comprehensive review of the literature found in the original study.

Independent of this, the second subsidiary problem was to obtain data concerned with the various aspects of personality of the students to be studied. In order to secure this information, a personal data sheet was prepared to be used in obtaining certain physical and social aspects of personality. This personal data sheet was administered to the groups of college students to be included in the study.

The third subsidiary problem was to administer the inventory of beliefs to the groups of college students used in the investigation.

Finally the fourth subsidiary problem was to analyze and interpret the results obtained on the inventory of beliefs. These results were studied in order to determine their relationship with the results obtained from the data on certain social and physical aspects of personality.

DEFINITION OF TERMS

1. Misinformation—As used in this study, misinformation is intended to indicate false judgment or information based on inadequate information. Misinformation, a general term, will include misconceptions and superstitions.

2. Misinformation About Sex—In order to limit the areas of sex under investigation and in order to facilitate statistical analysis, misinformation about sex will be limited to false information or lack of information in the following general areas: Body Size As It Relates to Sex; Contraceptions; Heredity; Homosexuality; Intercourse; Masturbation; Menopause; Menstruation; Pre-Natal Impressions; Reproductive Physiology; Seminal Emissions; Sex Determination; Venereal Diseases.

3. Personality—As used in this study personality is intended to indicate the total behavior of the individual as well as embodying the various social and physical characteristics of the individual which contribute to this total behavior.

4. Aspects of Personality—The aspects of personality are divided into two general areas; social and physical. The social aspect of personality has been determined by an analysis of the information received on the Personal Data Sheet which was designed to yield the following factors: marital status, nationality of parents, parents' education, number of siblings, religion, socio-economic status, source of sex information, field of interest, college class. The physical aspect of personality has been determined by an analysis of the information received on the Personal Data Sheet which was designed to yield the following factors: age, race, sex.

DELIMITATIONS

The subjects for this investigation were selected from students who were matriculated for the bachelor's degree and who were taking a required course in the Science Education Department at the School of Education of New York University. No graduate students were asked to participate.

The misinformation about sex to be studied and related to certain aspects of personality has been limited to those items considered to be crucial by the judges on the basis of the following criterion: significance in affecting man's adjustment to life situations.

Because of the nature of scientific progress there may, in time, be substantiated evidence refuting some statements in the inventory of beliefs. However at the time of this investigation the accuracy of the knowledge implied by the statements that made up the inventory of beliefs was judged in terms of: (1) selected sources of the informed literature commonly accepted as being authoritative in 1949–1950; (2) an authority in human physiology.

Concepts based on psychological theories were not included in the inventory of beliefs.

The aspects of personality were selected for consideration in this investigation on the basis of: their relation to the acquisition and persistence of information, their effect on learning and beliefs, their lending themselves to analysis and statistical treatment, and their value in indicating a possible relationship to misinformation about sex.

PROCEDURE IN COLLECTING DATA

In order to collect data that would be valuable in relating misinformation about sex to certain aspects of personality it was necessary to prepare: (1) an inventory of beliefs in the field of sex and (2) a personal data sheet.

The first task, the preparation of the inventory of beliefs, was accomplished in four stages. At first, it was necessary to determine the items of misinformation about sex, which were accumulated through an examination of the literature and through consultation of specialists in the field. In all, a total of 95 pamphlets, 63 studies and articles, 25 investigations, eight courses of study, 38 books, 19 radio scripts and two motion picture films dealing with sex, superstition, misinformation and misconception were viewed and examined for evidences and illustrations of statements of misinformation about sex. In addition, the 23 specialists who were interviewed and consulted for their aid in accumulating misinformation about sex were biologists dealing in human physiology, marriage counselors, nurses, physicians specializing in human fertility, psychiatrists, psychologists and social workers. The investigator discontinued further examination of additional material in the various types of literature and consultation of specialists in the various fields listed above after no new item of misinformation was found. The criterion used for selecting an item of misinformation about sex was that it could not be supported by scientific fact. The investigator's judgment concerning the scientific basis of the misconceptions was checked by an educator specializing in human physiology.

The second stage in the preparation of the inventory of beliefs was the compilation of the list of misinformation about sex. The statements of misinformation about sex gathered from the literature and from the specialists in the field were grouped and listed under the thirteen headings utilized in the definition of "Misinformation About Sex" (see page 4). The accuracy of the investigator's grouping of each statement under the appropriate heading was checked by five judges. A total of 164 items appeared on the categorized list of statements of misinformation about sex.

The third stage in the formation of a final inventory of beliefs was the evaluation of the list of misinformation about sex on the basis of the following criterion: significance in affecting man's adjustment to life situations. Two parents, two educators and two psychiatrists—each pair made up of a male and a female—were selected to act as judges in rating each item, utilizing the following scale: 4– high significance; 3– significance; 2– fair significance; 1– slight significance; 0– no significance. A rating sheet together with a letter of instruction was sent to each of the judges. Under each category of misinformation, space was provided for the judges to add items of misinformation about sex that were not listed by the investigator. Seven supplemental items were added in this manner. These seven items were then submitted to the six judges for evaluation. This made a total of 171 items of misinformation about sex. It was decided to limit the number of items selected for the final inventory to 100, since a larger number would be too cumbersome to use. On interpreting the results of the evaluation of the items by the judges it was found that 98 items received the total rating of 10 or more, indicating that these 98 items were considered to be at least of fair significance in affecting man's adjustment to life situations. On this basis, then, these 98 items were selected for use in the construction of the final inventory of beliefs.

The final stage was the construction of the final inventory of beliefs. In addition to the 98 items of misinformation selected for consideration, the investigator prepared 14 true items which were checked for their scientific accuracy as well as for their relationship to the other items of the inventory. The inventory was then checked for its validity and reliability. After applying tests for clarity, four items were eliminated from the final inventory. In the examination of the items for vocabulary difficulty, using the underlining method discussed by Curtis [3], the necessity for the use of a glossary of terms with the inventory of beliefs became evident. Examination of the items for ambiguity resulted in the revision of several statements.

Analysis of the consistency of the responses of students in each of the ten paired items on the inventory of beliefs indicated that the responses agreed 89.03 per cent of the time. As a further check on the reliability of the inventory of beliefs, a ten minute personal interview was designed by the investigator and checked by a psychiatrist for its validity. The interview was divided into three parts. Part I of the interview was conducted utilizing the non-directive method. Part II contained five statements which were corollaries of items chosen from the inventory at random, and to which the students responded orally before the investigator. Part III gave the students an opportunity to express themselves fully on issues, attitudes and acts contained in the inventory.

After these tests for the reliability and validity of the inventory of beliefs, each of the 108 items selected for the final inventory of beliefs was rewritten on to an index card. At random, the cards were selected and listed to form the final inventory of beliefs.

DESCRIPTION OF THE FINAL INVENTORY OF BELIEFS

The final inventory of beliefs, then, consisted of 94 false items and 14 true items, each listed in random order. To the left of each item were three categories for the students to choose from by marking a circle around the desired letter: B, U, or D: "B" indicating belief in the item; "D" indicating disbelief; "U" indicating uncertainty. In addition, after completing each item the students were required to write the letter of the reason or reasons for answering the questions as they did. A list of possible reasons was found under the directions for the use of the inventory. The reasons were:

(a) I have observed or experienced this.
(b) I studied or learned this in a course in school, or in a book.
(c) I heard this from someone.
(d) Everyone knows it isn't true.
(e) I do not understand the statement.
(f) I don't know anything about this subject.

Reasons a–f listed above were obtained as the result of a preliminary study.

After the construction of the final inventory of beliefs,[1] it was then necessary to determine the means of obtaining data concerned with certain aspects of personality.

OBTAINING DATA CONCERNING CERTAIN ASPECTS OF PERSONALITY

This second step necessitated the designing of a personal data sheet constructed to yield certain physical and social aspects of personality defined under "Aspects of Personality" in the *Definition of Terms*. The personal data sheet also had listed sources of sex misinformation or information and the students were asked to check and rank those sources that applied in his case. In addition, the investigator obtained data on the Minnesota Multiphasic Personality Inventory and the American Council on Education Psychological Examination from the permanent record files of some fifty students. This was later used in the discussion of selected comparisons of data.

After constructing the questionnaire and collecting data concerned with certain aspects of personality, the personal data sheet and the questionnaire were then adminis-

[1] The final inventory of beliefs will henceforth be referred to as *the questionnaire*.

tered to some 400 college students matriculated for the bachelor's degree taking a required course at the School of Education at New York University in the 1950–1951 semester.

TREATMENT OF THE DATA

By referring to a table of random numbers and using rigid criteria for rejecting or accepting questionnaires, a total of ninety subjects were ultimately selected. In scoring the questionnaire, all questions answered "U" were counted as incorrect. The grade assigned to each questionnaire was determined by subtracting the number of items answered incorrectly plus the number of items omitted from the total number of questions. The range of the total scores on the questionnaire was 38–98. Of the total number of students, 13.3 per cent received scores of 90 or better; 31.1 per cent received scores from 80–89; 23.3 per cent received scores from 70–79; 14.4 per cent received scores from 60–69; 11.1 per cent received scores from 50–59; 5.6 per cent received scores from 40–49; 1.1 per cent received scores from 30–39. The mean for the scores of the students was 74.6.

EVALUATING THE PERSONAL DATA SHEET

The primary concern in evaluating the Personal Data Sheet was to determine the I.S.C. Classification.[2] By assigning weights to occupation, source of income, house type and dwelling area, the I.S.C. Classification was determined to be either Upper Middle Class, Lower Middle Class, or Upper Lower Class.

DELIMITATION OF STATISTICAL ANALYSIS

In order to adequately handle the statistics it was necessary to limit the analysis to under five variables. In addition, because of rigid adherence to the criteria set forth in the random selection of questionnaires, the variables selected for statistical analysis were ultimately socio-economic status, religion and sex. These variables were selected because of their possible relationship to misinformation as found in previous work in the literature, although the conclusions reached by previous investigators were often conflicting. In addition, they were selected for their possible bearing on teaching methods and pupil grouping.

STATISTICAL TREATMENT OF THE DATA

The statistical design appropriate for the treatment of the data is the analysis of variance with a 3 x 3 x 2 design. Using the analysis of variance, the mean square for the within variation was found to be 194.95, and the mean square for the between variation was 214.57, with 72 and 17 degrees of freedom respectively. The F ratio was 1.10, which is not significant at the .05 level of confidence. Using only this much information the null hypothesis is accepted indicating that the samples are random samples from a common normal population, and that the means of the groups do not differ significantly among themselves. However, the F' ratio for the variation between sex is 4.56, which has a probability between .01 and .05. Therefore in this instance, the null hypothesis is rejected, indicating that the mean of the male sample differs significantly from the mean of the female sample; that is, the means of the two groups show more variation than can be attributed to random sampling from populations with a common population mean. Consequently, it may be inferred that the differences in sex misinformation between males and females are indicative of real differences.

Since a real sex difference has been noted for the questionnaire in its entirety, the chi square test of significance may be used to determine in which categories there are real sex differences. The questionnaire contains thirteen categories of misinformation, therefore it was necessary to obtain chi square values for each one of the thirteen categories. Analysis of the data deter-

[2] The letters I.S.C. will be used to indicate the Index of Status Characteristics in predicting social class placement.

mined real differences in sex misinformation between males and females in the areas of heredity, menstruation, and venereal diseases. By referring to the raw data and the means for each group it was found that males are more misinformed than females in the areas of menstruation and heredity and that females are more misinformed than males in the area of venereal diseases. By solving for the contingency coefficient it was concluded that there is a greater relationship between misinformation about menstruation and the sex of the respondent than between misinformation about heredity or venereal diseases and the sex of the respondent.

Since a significant difference between the sexes was demonstrated, additional tests were applied designed to eliminate the sex factor. Males and females were considered separately in an analysis of the means for the three social classes and for the three religions. Analysis of the T scores computed indicated that the results, at the .05 level of confidence with 28 degrees of freedom, were not significant. Even on applying the one tail test, the results were not significant. These findings indicated, then, that there is no relationship between (1) misinformation about sex and socio-economic status and (2) misinformation about sex and religion, and further confirmed the results of the analysis of variance.

SPECIFIC FINDINGS

Although the F ratio obtained through the analysis of variance was not significant at the .05 level of confidence, further investigation demonstrated that the F′ ratio for the variable *sex* was significant, while the F′ ratios for the variables *socio-economic status* and *religion* were not significant. The results obtained for the F′ ratios suggest, then, that females have less misinformation about sex than males, and that an individual's socio-economic status and religion have no relationship to his misinformation about sex. The finding that socio-economic status and religion have no relationship to misinformation about sex was further verified by an analysis of means, in which the sex factor was eliminated. In addition, it was found through the use of the chi square test of significance that there are real differences in sex misinformation between males and females in the areas of heredity, menstruation and venereal diseases: it was found that males are more misinformed than females in the areas of menstruation and heredity and that females are more misinformed than males in the area of venereal diseases.

GENERAL CONCLUSIONS

While it is difficult to generalize for other groups it would appear on the basis of this group alone that a score of 74 or below on the questionnaire is considered below average. Since this score indicates thirty-four items of misinformation it is especially significant when one considers that the items of misinformation on the questionnaire were selected for their significance in affecting man's adjustment to life situations. We may also imply from the data obtained that among entering Freshmen in colleges in large metropolitan areas representing heterogeneous groups, there is a good deal of misinformation about sex.

RECOMMENDATIONS

In addition to the three variables selected for statistical analysis in this study, additional variables as mentioned in the personal data sheets, should be analyzed for their possible relationship to misinformation about sex. The extension of the use of the questionnaire as a supplement to emotional tests for psychologists could be explored.

On the basis of the finding of a sex difference in misinformation coupled with the conclusion that, in males, there is more misinformation about bodily functions of the opposite sex, the curriculum and reading matter of hygiene courses, physiology courses, pre-natal instruction, preparation for marriage courses and the like should be extended to include the normal bodily processes of both sexes. Whether this should be done in a mixed group, or in separated groups of males and females should be determined by future research designed to yield the better learning situation. Guidance counselors, PTA groups, workers in adult education and marriage counselors should be aware of the need for "teaching about the opposite sex." In addition, to assist the classroom teacher in removing misinformation and fears, the psychiatric and counseling services in schools should be extended.

It appears, from the material analyzed in the review of the literature, as well as from the conclusions reached by this study that there is a good deal of misinformation about sex. In addition it follows that regular classroom teaching has failed to eliminate this misinformation. This indicates that the rational, sometimes authoritarian approach does not succeed, necessitating the use of varied teaching methods. To meet this need, additional training of teachers in non-directive techniques, particularly in a group situation, would seem vital. Applied to the classroom situation this would mean original acceptance of the student's misbeliefs, exploration of *why* the student feels he is correct and *how* he happened to learn that he is correct. As a curriculum implication, possible examination of misbeliefs on an anthropological and sociological basis as a classroom project might be undertaken to indicate initial group acceptance. Thus, instead of rejecting the student's misbeliefs—and possibly the student, and hence his willingness to learn *fact*—the student's misbeliefs are accepted for what they are, are explored by the group in proper perspective, and then are shown to be incorrect through the presentation of fact, in the form of problem solving. This method might reduce the complex emotional factors that make it difficult for a student to rid himself of a misconception, since many misconceptions are learned first and hence tend to persist, even when facts are presented.

Since sex education may be thought of as an integral part of the gradual growth of an individual, commencing in infancy, much of the early impressions of a child may influence his attitude toward sex, both on an emotional and on a factual basis. Hence Adult Education groups should be extended to include informal discussions in sex education, using the teaching methods outlined in the previous paragraph. Throughout all of this work the teacher or group leader should maintain a prevailing attitude of permissiveness. If much of the misinformation, fears and doubts of parents and prospective parents can be removed, there will be conveyed to future generations a positive, happier and healthier approach to sexuality.

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PERSONALITY ASPECTS RELATED TO MISINFORMATION ABOUT SEX AMONG COLLEGE STUDENTS: QUESTIONNAIRE ANALYSIS

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In another article * this investigator discussed the relationship between misinformation about sex manifested in a group of college students and certain social and physical aspects of personality.† As an integral part of this study, an inventory of beliefs—or questionnaire—was constructed, administered and evaluated.

PURPOSE

It is the purpose of this article to analyze the items of misinformation about sex in the questionnaire, on the basis of student error, to:

1. Provide a statistical summary of the responses to the items on the questionnaire.
2. Rank the items on the questionnaire with respect to student error, ranging from items of greatest error to items of smallest error.
3. Indicate items and areas where there is misinformation.
4. Show the difference in error on each item with respect to the sex of the students.
5. Assist in the removal of misinformation about sex through the recognition of the types of misconceptions commonly held by college students and the extent to which these misconceptions are commonly held.

BACKGROUND

In the 1950–1951 semester some 400 questionnaires were completed by students at New York University. Ninety subjects were ultimately selected: forty-five male students; forty-five female students. The questionnaires contained ninety-four items of misinformation and fourteen true items listed in random order. The grade assigned to each questionnaire was determined by subtracting the number of incorrect items from the total number of questions. The range of scores was 38–98; the mean score was 74.6.

In addition to the questionnaire, a personal data sheet was prepared and submitted to the students in order to obtain data on certain aspects of personality required for the investigation.

* See *Science Education,* this issue, page 156.

† Based on thesis entitled, "The Relationship Between Misinformation About Sex Manifested in a Group of College Students and Certain Social and Physical Aspects of Personality," submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, New York University.

FINDINGS

While a detailed discussion concerning the procedure, treatment of data and specific conclusions are beyond the scope of this report, some general findings will be listed in order to place the analysis of the questionnaire in its proper perspective.

Through the use of the analysis of variance it was found that females have less misinformation about sex than males, and that socio-economic status and religion have no relationship to misinformation about sex.

The chi square test of significance determined real differences in sex misinformation between males and females in the areas of heredity, menstruation and venereal diseases: that males are more misinformed than females in the areas of menstruation and heredity and that females are more misinformed than males in the area of venereal diseases.

In the analysis of means, computation of t scores confirmed the finding of the analysis of variance, namely, there is no significance between misinformation about sex with respect to socio-economic status and religion.

DEFINITION OF TERMS

To avoid ambiguity and to assist in the interpretation of the findings and in the analysis of the questionnaire, the following terms are defined:

1. Misinformation, including misconceptions and superstitions, is intended to indicate false judgment or information based on inadequate information.
2. Personality is intended to indicate the total behavior of the individual as well as embodying various social and physical characteristics which contribute to this total behavior.
3. Misinformation about sex is limited to the following general areas:

I Body Size as It Relates to Sex
II Contraception
III Heredity
IV Homosexuality
V Intercourse
VI Masturbation
VII Menopause
VIII Menstruation
IX Pre-Natal Impressions
X Reproductive Physiology
XI Seminal Emissions
XII Sex Determination
XIII Venereal Diseases

The Roman number that appears to the left of each of the above areas is given for reference, in order to assist in the interpretation of Table I, pages 164–167. In this table, only the Roman numbers are listed under the heading "Category Number."

QUESTIONNAIRE ANALYSIS

Table I is an analysis of the questionnaire items dealing with misinformation about sex that was submitted to ninety undergraduate college students—forty-five male students, forty-five female students, ranked according to frequency of total student error on each item.

TABLE I

QUESTIONNAIRE ITEMS OF MISINFORMATION SUBMITTED TO 90 UNDERGRADUATE STUDENTS RANKED ACCORDING TO FREQUENCY OF ERRORS

Category No.	Item No.	Item	Per Cent Male Error	Per Cent Female Error	Per Cent Total Errors
X	90	Every woman has a "safe period" each month during which time sexual intercourse can take place without her becoming pregnant	93.3	97.8	95.6
II	93	Withdrawal of the penis before the male reaches sexual climax during sexual intercourse is a safe method of birth control.	77.8	88.9	83.3
VI	31	Masturbation is one of the causes of nervous tremors.	80.0	86.7	83.3
XIII	28	Sitting on a wet toilet seat may cause syphilis and other venereal diseases.	75.6	88.9	82.2
II	50	A douche prevents conception.	82.2	73.3	77.8
X	38	A woman can't conceive immediately before or immediately after her menstrual period.	71.1	82.2	76.7
II	68	All contraceptives on the market have been scientifically tested and approved by government agencies.	57.8	86.7	72.2

TABLE I (Continued)

Category No.	Item No.	Item	Per Cent Male Error	Per Cent Female Error	Per Cent Total Errors
XI	73	Girls begin to menstruate in their early teens, while boys go through a similar regular process which resembles menstruation.	64.4	77.8	71.1
I	2	A woman has a hymen until sexual intercourse occurs.	77.8	62.2	70.0
V	3	Women do not reach sexual climax unless they are conscious of an ejaculation of fluid.	64.4	75.6	70.0
X	35	A woman cannot become pregnant unless the man's penis is in her vagina at the time of sperm discharge.	57.8	82.2	70.0
XIII	16	Venereal diseases are inherited.	68.9	68.9	68.9
III	53	The marriage of first cousins results in children whose intelligence is lower than normal.	53.3	80.0	66.7
X	56	If a woman has a child born through Caesarian operation, any other children she may have will have to be born through a Caesarian.	71.1	62.2	66.7
V	106	Certain foods are sexually stimulating.	84.4	44.4	64.4
VIII	15	Cold foods or drinks will cause a girl who is menstruating to get cramps.	88.9	40.0	64.4
VIII	62	The menstrual discharge enables a woman's body to rid itself of poisonous substances.	86.7	35.6	61.1
X	74	The period of ovulation is the "safe period" during which time after sexual intercourse, pregnancy cannot occur.	60.0	60.0	60.0
VI	25	Masturbation causes muscular weakness.	48.9	68.9	58.9
V	41	A man needs sex relations to keep his testicles healthy.	40.0	75.6	57.8
VIII	82	It is risky for women to shampoo hair during menstruation because they are more susceptible to colds then.	80.0	33.3	56.7
II	43	If birth control methods are used, it will take a longer period of time than normal to conceive after discontinuing the birth control methods.	46.7	64.4	55.6
V	86	Sexual intercourse is necessary to normal growth and health.	57.8	53.3	55.6
VIII	103	The normal menstrual period is accompanied with pain.	88.9	17.8	53.3
XII	54	X-rays can accurately determine the sex of the unborn child developing within the mother.	55.6	51.1	53.3
V	30	The eating of red meat is one of the causes of increased virility.	55.6	48.9	52.2
V	47	A girl must bleed at her first act of sexual intercourse if she is a virgin.	48.9	53.3	51.1
VI	72	Masturbation causes a loss of virility.	46.7	51.1	48.9
VI	17	Excessive masturbation causes insanity.	40.0	55.6	47.8
X	107	A woman cannot become pregnant unless she and the man experience sexual climax together.	48.9	46.7	47.8
VIII	77	To be perfectly normal a girl must menstruate for at least five days each month.	82.2	11.1	46.7
X	100	A nursing mother cannot become pregnant.	42.2	46.7	44.4
X	55	If a woman urinates after sexual intercourse she cannot become pregnant.	44.4	44.4	44.4
I	40	If a boy handles a girl's breasts or hips they become larger.	46.7	40.0	43.3
III	91	If close relatives marry and then have children, the children are likely to be insane.	46.7	40.0	43.3
IV	21	Women who practice homosexuality are physically unable to have normal sexual relations with men.	26.7	60.0	43.3
VIII	101	Girls should avoid all exercise during menstruation.	84.4	2.2	43.3

TABLE I (Continued)

Category No.	Item No.	Item	Per Cent Male Error	Per Cent Female Error	Per Cent Total Errors
VIII	94	If a girl doesn't start to menstruate in her 'teens, she will die because of accumulated poisons.	62.2	22.2	42.2
V	52	The eating of oysters or other types of seafood increases sexual desire.	51.1	28.9	40.0
VIII	65	No local bathing should be done during the menstrual period.	71.1	8.9	40.0
X	60	Babies are conceived at the navel of the mother.	44.4	35.6	40.0
III	48	A child is more closely akin to the mother than to the father.	35.6	42.2	38.9
V	45	A woman is not a virgin unless she experiences pain at her first act of sexual intercourse.	46.7	31.1	38.9
VI	24	Masturbation is one of the causes of cancer.	40.0	37.8	38.9
VIII	6	Sexual intercourse during menstruation is not possible.	55.6	22.2	38.9
VI	42	Masturbation causes a loss of thinking power.	33.3	42.2	37.8
VIII	20	Normal unmarried girls cannot use tampons during menstruation.	51.1	24.4	37.8
II	44	Birth control methods will prevent a husband and wife from having a baby when they want one, after discontinuing the birth control methods.	28.9	42.2	35.6
V	108	Miscarriages are due to sexual intercourse during pregnancy.	42.2	28.9	35.6
XIII	22	All venereal diseases cause sterility.	20.0	48.9	34.4
II	76	Contraception is one of the causes of cancer.	35.6	33.3	34.4
IX	49	A child can be deformed or marked because something frightened or shocked the mother while she was pregnant.	44.4	22.2	33.3
IV	27	Homosexuality prevents an otherwise normal person from having children, even if he were to have normal intercourse.	26.7	37.8	32.2
VIII	8	It is dangerous to take baths or showers during the menstrual period.	62.2	2.2	32.2
XIII	9	The only way of contracting a venereal disease is through sexual intercourse.	26.7	37.8	32.2
XIII	88	Urinating after sexual intercourse prevents the venereal diseases.	24.4	37.8	31.1
IV	66	Women who practice homosexuality are not able to have sexual intercourse with men.	26.7	33.3	30.0
VI	63	Masturbation causes pimples.	22.2	37.8	30.0
V	19	Throughout pregnancy, women cannot have sexual intercourse.	31.1	24.4	27.8
VIII	36	Women are by nature purer and nobler than men.	20.0	35.6	27.8
XIII	79	Once having recovered from a venereal disease, you can never get it again.	13.3	42.2	27.8
I	34	A woman is not a virgin unless she has a hymen.	37.8	15.6	26.7
IV	70	Women who do not enjoy male companionship are homosexuals.	24.4	28.9	26.7
X	97	Frigid women can't have babies.	20.0	33.3	26.7
X	102	If a baby born without limbs had remained inside the mother for a few more months beyond the nine months, it would then be born with all its limbs intact.	35.6	15.6	25.6
XI	59	Seminal emissions are signs of weakness.	26.7	24.4	25.6
III	85	Exposure of a prospective father or mother to X-rays causes morons to be born to them.	31.1	17.8	24.4
X	87	For the woman to become pregnant there is only one position possible during sexual intercourse.	22.2	26.7	24.4
IX	80	If a pregnant woman is hit in the stomach, her child, when born, will have a birthmark.	28.9	17.8	23.3
XI	92	Seminal emissions occur only in boys who masturbate.	24.4	22.2	23.3

TABLE I (Continued)

Category No.	Item No.	Item	Per Cent Male Error	Per Cent Female Error	Per Cent Total Errors
III	11	If the wife is beautiful and her husband is handsome, they will have beautiful children.	35.6	8.9	22.2
V	81	After removal of the ovaries there can be no more sexual intercourse for the woman.	24.4	20.0	22.2
III	18	A child is more closely akin to his father than to his mother.	20.0	22.2	21.1
VII	98	After menopause there can be no more sexual intercourse for the woman.	24.4	17.8	21.1
V	89	The appearance of skin pimples and boils is due to excessive sexual intercourse.	20.0	20.0	20.0
III	14	If a man was crippled or shell-shocked in the war, he can't have normal, healthy children.	24.4	11.1	17.8
VII	84	Menopause ends the marriage relations of husband and wife.	26.7	8.9	17.8
IX	61	The talents of a child can be affected by the mother's mental impressions before the child's birth.	22.2	11.1	16.7
V	57	The appearance of skin pimples and boils is due to lack of sexual intercourse.	15.6	15.6	15.6
IX	71	The skin of a child can be marked by the mother's mental impressions before the child's birth.	20.0	11.1	15.6
XIII	64	If a woman has sexual intercourse during menstruation, she will contract a venereal disease.	24.4	6.7	15.6
IX	51	If a pregnant woman grabs herself when she is frightened, her child when born will have a birthmark on that spot.	22.2	6.7	14.4
XII	67	A sodium bicarbonate or alkaline douche before sexual intercourse will cause the woman, if she becomes pregnant, to have a boy; an acid douche will cause her to have a girl.	17.8	11.1	14.4
IX	83	An expectant mother, by fixing her mind on a subject, can influence the character of her unborn child.	20.0	4.4	12.2
VIII	4	Flowers will die if a menstruating woman touches them.	17.8	6.7	12.2
VII	33	Women always become insane during menopause.	15.6	4.4	10.0
X	37	Babies are born from the rectum of the mother.	8.9	11.1	10.0
VI	10	If a person masturbates he will be unable to have children when he wants them.	11.1	4.4	7.8
IX	7	If a pregnant woman sees a mouse, a birthmark will appear on the infant when born.	6.7	8.9	7.8
V	75	Boys who do not have sexual intercourse by the the time they are in their early twenties, sooner or later become insane.	8.9	4.4	6.7
XIII	29	A venereal disease occurs as a direct punishment for some particular wrong-doing.	6.7	2.2	4.4
IX	26	If a pregnant woman attends concerts, her child, when he matures, will appreciate music.	8.9	0.0	4.4
IX	13	If an expectant mother sees a person with a birthmark, her child will also have a birthmark.	4.4	0.0	2.2
X	99	A girl can become pregnant by kissing a boy she likes.	2.2	0.0	1.1

RECOMMENDATIONS

There appears to be a good deal of misinformation about sex. It follows that regular classroom teaching has failed to eliminate this misinformation. In addition to the extension of psychological and psychiatric school services, curriculum enrichment and varied teaching methods may be indicated. Additional teacher training in non-directive techniques to establish initial permissiveness coupled with examination of misbeliefs on anthropological and sociological bases might establish a more acceptable environment for the willingness to learn fact. In addition, Adult Education groups in sex education should be extended.

It is hoped that the presentation of the questionnaire analysis will assist in the dissolution of misinformation. If much of the misinformation and fears of parents and prospective parents are removed, there will be conveyed to future generations a positive, happier and healthier approach to sexuality.

TEACHING GAS LAW PROBLEMS IN HIGH SCHOOL SCIENCE

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MATHEMATICAL calculations involving simple algebra are encountered in all physical science courses. Preparation of the student in mathematics before he reaches these courses should be a concern of all physical science teachers.

Generally, students have no difficulty with simple mathematical problems of finding unity as, 2 apples cost 5 cents one (unity) costs 2½ cents. Reversing the problem, how many apples can be bought for 75¢ if 14 applies cost 35¢, presents little difficulty. But, if a problem is given to the effect that, 4/7 of a pumpkin costs 52¢, what is the cost of one pumpkin, the arithmetic, or elementary algebra involved, in reaching a solution, does give a number of students some trouble. Here, command of simple algebra could lead to an easy solution of the problem and the student could work toward a solution with a procedure in mind. It is when the gas laws and chemical problems are subjected to mathematical calculations [1] that a degree of lethargy develops unless the student can clearly see a means to an end, that is, the solution to the problem. Yet this does not mean to say that all students will seek the solution merely because they know how. In this research, promoting stimulation in students to solve gas law problems dwelt on the premise that, if the student could work the problem to an end—regardless of his ability in algebra—his interest could be held a little longer and perhaps his thinking processes somewhat encouraged. This was an objective in dealing with the experimental group of students. However, for this research the solution to the gas law problems involved, in the research work for both control and experimental groups, was considered correct if the proper "set-up" was obtained. The arithmetic in reaching an answer was disregarded.

The purpose of the research was to determine which method of teaching the gas laws benefited the greater number of students.

During the class work on the gas law problem two approaches were made in the presentation. One was to try to reason out the problem from the given data. The other was a slight variation of a formula method. The classes that were taught by the "formula variation" method were used as the control group and consisted of 100 students

[1] M. M. Gunkle, "Striving for an Approach in Teaching Chemical Problems to High School Students," *Journal of Educational Research*, November, 1956, 221–225.

in the school year 1954–55, 112 students in the school year 1955–56, and 102 students in 1956–57. The experimental group consisted of 70 students in the school year 1954–55, 101 students in the school year 1955–56, and 75 students in 1956–57.

INSTRUCTION PRIOR TO TESTING FOR THE CONTROL GROUP

Explaining the formula variation method of the gas laws consisted merely of stating the conditions in the problem. As an example, the volume before the conditions in the problem changed was called the starting volume or "initial volume," abbreviated I V; the temperature was called an initial temperature, I T; the pressure, an initial pressure, I P. Under the changed conditions in the problem the volume was called a final volume, F V; the temperature change, a final temperature, F T; and the pressure change, a final pressure, F. P. This type of lettering system was used after consulting the classes making up the control group. It seemed the students were able to understand the items that were undergoing change better as well as having the information condensed so as to scan the problem quickly. (Students seemed to understand the above abbreviations better than the classical P_1 to P_2, V_1 to V_2, and T_1 to T_2). The gas law formula (at the secondary level) was then set-up to represent a volume change as,

$$FV = \frac{IV \times FT \times IP}{IT \times FP}.$$

Students were asked to commit the formula to memory. Now, there should be no difficulty if all problems called for the solving of a final volume. But some problems involved the solving of pressure, temperature, and initial volume, thus bringing about a transposition and then solving for the unknown quantity.

Preliminary problems involving both Charle's law, which also enveloped absolute or Kelvin temperature, and Boyle's law,

Example 1. The volume of a gas was measured at a temperature of —87 degrees centigrade. When the temperature was changed to 99 degrees centigrade the volume was 1,000 milliliters. What was the initial volume? Pressure is constant.

Data: I V = ?

I T = 186 K

F T = 372 K

F V = 1,000 ml.

First step: $FV = \frac{IV \times FT}{IT}$

Second step: $1{,}000 = \frac{IV \times 372}{186}$

Proper set-up: $IV = \frac{1{,}000 \times 186}{372}$

Much difficulty was met here.

Example 2. 500 liters of a gas were measured when the temperature was —87 degrees centigrade. On the following day the volume is still 500 liters at a temperature of 99 degrees centigrade and 900 mm pressure. What pressure was the gas exerting on the previous day?

Data: I V = 500 L.

I T = 186 K

I P = ?

F V = 500 L.

F T = 372 K

F P = 900 mm

First step: $FV = \frac{IV \times FT \times IP}{IT \quad FP}$

Second step: $500 = \frac{500 \times 372 \times IP}{186 \quad 900}$

Proper set-up: $IP = \frac{500 \times 186 \times 900}{500 \quad 372}$

Much more difficulty was met here.

were dealt with separately by formula for finding the volume change. These examples will not be shown. Examples of the type of problem that presented some difficulty are given.

With the data before him the student can see what is involved in each problem. Actually this method involves separating the starting conditions from the changed conditions in the problem. It is then a typical formula substitution that has been performed by the control group with the solution involving the use of simple algebra. Generally, students can substitute in the formula. From this point many could go no further to get the proper set-up and show the arithmetic for solving the problem. This was the point that was to be compared with the experimental group.

INSTRUCTION PRIOR TO TESTING IN THE EXPERIMENTAL GROUP

The experimental group practiced a different approach to the solving of problems involving the gas laws. No formula was introduced to the experimental group so this group of students used none.

Usually students are familiar with the statement "heat a gas—it expands, cool a gas—it contracts, pressure being constant; to decrease the volume of a gas—increase the pressure, to increase the volume of a gas—decrease the pressure, temperature being constant." Another phase of the gas law is introduced here, it being that "increase the temperature of a gas increases the pressure, decrease the temperature of a gas decreases the pressure, volume being constant." This is sometimes referred to as Gay-Lussac's gas law. Instruction centered around the above statements. During the explanation of the absolute or Kelvin scale of temperature, it was shown that the increase in volume of a gas is in proportion to a temperature increase, and vice versa. Thus, if a volume of gas was given at one temperature, the volume increased if the temperature increased; and this increase was brought about by a temperature fraction greater than unity being multiplied by the original volume. As will be seen, a primary concern in this part of the experiment was that of setting up the problem properly and solving for the unknown quantity without the use of algebraic transposition. As an example:

20 liters of a gas at 200 K has what volume at 300 K; pressure being constant?

Charle's law is applied in the calculation of the problem. In this problem the student had to keep in mind that "increase in temperature increases the volume of the gas" so the original volume of 20 liters must be multiplied by the fraction $\frac{300}{200}$ thusly, $\frac{20 \times 300}{200}$.

Students were asked to follow a schematic procedure that would give a clear picture of the problem. The following was suggested and explained and most of the pupils followed this scheme.

	volume	temperature
start	20	200 K
end	?	300 K

The end volume is a result of the known volume multiplied by a fraction conforming to the law—increase in temperature is followed by an increase in volume, pressure being constant. The fraction $\frac{300}{200}$ demonstrates Charle's law. Then $V = \frac{20 \times 300}{200}$. The proper set-up is obtained directly. No algebraic transposition is necessary.

Dealing with Boyle's law the same procedure was adopted—that of making the change in volume conform to the law: "increase the pressure the volume decreased and vice versa," temperature being constant. Along with this an explanation of the meaning of "mm of Hg pressure" was given and demonstrated.

Example 2. 2,000 liters of a gas at 200 mm Hg pressure will have what volume at 500 mm Hg pressure, temperature being constant?

	volume	pressure
start	2,000 liters	200 mm
end	?	500 mm

The end volume is a result of the known volume multiplied by an arithmetical fraction conforming to the law—increase in pressure is followed by a decrease in volume, temperature being constant.

$$V = \frac{2{,}000 \times 200}{500}$$

The changed condition of the gas exhibits a smaller volume because of an increase in pressure, and the changed condition must be a fractional part of the volume at the start. In this instance the fractional part is smaller than the given volume because of the increased pressure. The fraction $\frac{200}{500}$ demonstrates the law.

Dealing with a pressure change due to a temperature change takes into account the statement of "increase the temperature the pressure increases, and vice versa, volume being constant."

Example 3. If the pressure on a gas is 600 mm Hg at a temperature of 200 K what will be the pressure if the temperature is increased to 300 K, the volume being constant.

	pressure	temperature
start	600 mm Hg	200 K
end	?	300 K

The end pressure is a result of the known pressure multiplied by a fraction conforming to the law—increase in temperature is followed by an increase in pressure, volume being constant.

$$P = \frac{600 \times 300}{200}$$

The fractional number $\frac{300}{200}$ has demonstrated the principle of the law.

Now after the laws had been explained separately, came the task of combining them. It was explained that the principle of each law acted independently and that this was the basis of the gas laws. A problem of this type is given as follows:

Example 4. The volume of a gas at 200 K and 600 mm Hg pressure was 2,000 cubic centimeters. What volume will the gas have if the temperature is 100 K and the pressure 800 mm Hg?

	volume	temperature	pressure
start	2,000 cc	200 K	600 mm
end	?	100 K	800 mm

Change in volume results from a change in temperature and change in pressure.

temperature decreases—volume decreases

$$\text{fraction} = \frac{100}{200}$$

pressure increases—volume decreases

$$\text{fraction} = \frac{600}{800}$$

setting up the problem:

$$V = \frac{2{,}000 \times 100 \times 600}{200 \quad 800}$$

Example 5. (Dealing with pressure change) 300 liters of a gas were measured when the temperature was 186 K and the pressure 900 mm. If the volume now is 450 liters at a temperature of 372 K what must the pressure be?

volume		temperature	pressure
start	300 L	186 K	900 mm
end	450 L	372 K	?

temperature increases—pressure increases

$$\text{fraction is } \frac{372}{186}$$

volume increases—pressure decreases

$$\text{fraction is } \frac{300}{450}$$

setting up the problem:

$$P = \frac{900 \times 372 \times 300}{186 \quad 450}$$

Change in pressure results from a change in temperature and volume. End pressure is a result of the known pressure multiplied by the fractional temperature and volume changes. As shown by the above examples, problem solving in the experimental group avoids the use of simple algebraic transposition and sets up the problem mathematically correct provided the correct reasoning is employed.

The problem of "student readiness" for an examination in the work dealing with both the experimental and control groups was disregarded and both groups were tested after ten daily class periods of time (two weeks) had elapsed in problem solving and discussion. As was previously stated, solution to problems was considered correct if the "set-up" was proper.

BRIEF SYNOPSIS

This study dwelt on the problem of comparing two methods of teaching the gas laws to high school students during the years 1954 through 1957 and involved three different sets of students divided into an ex-

TABLE I

COMPARING DATA BETWEEN EXPERIMENTAL GROUP AND CONTROL GROUP

	School Year 1954–55			1955–56			1956–57				
Number of Problems	Number of Students Solving Number of Problems Correctly	Per Cent Getting Correct Solution	Average IQ of Group	Number of Students Solving Number of Problems Correctly	Per Cent Getting Correct Solution	Average IQ of Group	Number of Students Solving Number of Problems Correctly	Per Cent Getting Correct Solution	Average IQ of Group	Total Number of Students With Correct Solution to Number of Problems	Per Cent of Combined Groups Getting Correct Solutions to Number of Problems
Experimental Group (simplified method of arithmetic)											
5	12	17.1	B–111	27	26.7	B–115	14	18.8	B–112	53	21.5
4	12	17.1	G–114	19	18.8	G–119	18	24.0	G–112	49	20.0
3	11	15.7	Combined–112	20	19.8	Combined–116	17	22.6	Combined–112	48	19.5
2	19	27.1		20	19.8		13	17.3		52	21.1
1	14	20.0		8	7.9		10	10.3		32	13.0
0	2	3.0		7	7.0		3	4.0		12	4.9
Total	70	100.0		101	100.0		75	100.0		246	100.0
Average number of correct solutions to problems per student			2.7			3.2			3.0		3.0
Control Group (formula method of arithmetic)											
5	10	10.0	B–109	19	17.0	B–99	13	12.8	B–104	42	13.4
4	17	17.0	G–117	16	14.2	G–105	20	19.6	G–110	53	16.8
3	22	22.0	Combined–111	30	26.8	Combined–100	16	15.7	Combined–105	68	21.7
2	22	22.0		17	15.2		21	20.6		60	19.1
1	20	20.0		13	11.6		23	22.5		56	17.8
0	9	9.0		17	15.2		9	8.8		35	11.2
Total	100	100.0		112	100.0		102	100.0		314	100.0
Average number of correct solutions to problems per student			2.6			2.8			2.5		2.6

B—boys; G—girls.

TABLE II

SHOWING AVERAGE NUMBER OF PROBLEMS SOLVED AND RETENTION AVERAGE FOR THE DIFFERENT AGE GROUPS

School Years of 1955–56 and 1956–57	Age Range in Years and Months	IQ Range	IQ Average	Average Number Problems Solved of Possible Five	Retention Average Based on Two Problems
Experimental group	17^{6}–17^{11}	82–90	B–86	2.7	0.3
			G–none		
			Combined–86		
Control group			B–89		
			G–none		
			Combined–89	2.0	0.0
Experimental group	17^{0}–17^{5}	86–99	B–94		
			G–none		
			Combined–94	2.5	0.25
Control group			B–94		
			G–none		
			Combined–94	1.67	0.0
Experimental group		100–112	B–109		
			G–none		
			Combined–109	3.0	0.4
Control group			B–108		
			G–none		
			Combined–108	1.4	0.0
Experimental group	16^{6}–16^{11}	110–120	B–116	4.43	2.0
			G–111	3.3	1.0
			Combined–115	4.1	1.7
Control group			B–115	3.8	0.6
			G–114	4.0	1.0
			Combined–114	3.9	0.75
Experimental group	16^{0}–16^{5}	110–120	B–115	3.8	1.5
			G–115	2.7	1.0
			Combined–115	3.6	1.3
Control group			B–116	3.4	1.2
			G–115	4.5	1.0
			Combined–116	3.6	1.1

perimental group and a control group. The first study was based on the average I.Q. obtained from the Hinman-Nelson test. Table I compares the data from the three sets on this basis only. Although not too significant but consistently the experimental group is shown to have the better average in problem solving. This result indicated that a further and closer study should be made along more scientific procedures.

After the data in Table I was simulated 68 students (58B 10G) of the 1955–56 and 1956–57 control group were matched with 62 students (50B 12G) of the 1955–56 and 1956–57 experimental group. The two groups were matched as to age, I.Q., and sex. Table II shows the boys in each case of the experimental group, having a better average in problem solving than the control group. Comparison based on age shows the experimental group consistently averaging better in problem solving than in the control group. The reverse was found with girls. The overall average for problem solving in the whole experimental group was higher than that of the whole control group.

The column headed "Retention" was based on an examination consisting of two problems, one dealing with Boyle's law and the other with Charle's law. No coaching or practice was given for these two problems which occurred on the same examination paper that covered a different unit in chemistry. Students that made up both control and experimental groups of the last two years worked the same two problems. Time that had elapsed between the end of the study on the gas laws and the examination containing the two problems was two and one-half weeks (13 school days). Better retention is shown by the experimental group when broken down by ages. Table II also shows the data for this branch of the study.

CONCLUSION

From this research a comparison of data shows that teaching problems related to the gas laws to high school students in a manner that circumvents algebraic manipulations is advantageous. This takes in all the IQ groupings. The study also shows that retention of the work covered is greater when this procedure in teaching is used.

PHYSICAL SCIENCE IN THE JUNIOR COLLEGE OR THE LOWER DIVISION OF A UNIVERSITY

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THE Physical Science course referred to in this paper is one offered as a required course to first or second year students in a junior college or the lower division of a university. In organizing such a course there are some basic principles which should be used so that students and professors may reach a common understanding and from there proceed to scientific thinking. Frequently because of their simplicity the principles are ignored and confusion results. Because creative effort and scientific thinking are only possible when they have a solid foundation, a brief analysis of the nine bases of reasoning and procedure follows.

The first of these principles is the imagery by which we conceive phenomena. Imagery may be a beginning and also a final step in scientific thinking as well as in other fields of endeavor. Scientific imagery may not be possible for all the students but there are many who can be guided to reach this high level of attainment so memorable and so rewarding both immediately and after long range contemplation. Since no one can hope to encompass factually all of one field the student must be led to the formation of images that will serve him indefinitely as bases for additional learning, a highly retained reference in advanced reading and a source of delight because of the facility of additions to the framework of thought. These images may differ for different students; but properly taught they have fundamental likenesses which explain, identify, and symbolize when language fails.

The second basic principle lies in an examination of the past which may point the best way to a presentation of the immediate. As man has learned so young people may learn. The provision of food and shelter was not enough for early man. An inquiry of environment gave satisfaction when it resulted in changes and improvements. As man looked about him to measure the periodic phenomena of his universe so the student can be directed to look about and find available units for measuring his environment. In the physical sciences a presentation in the order of man's advance in that field may lead to the student's progress towards an understanding, appreciation, and realization of his physical environment and may make him able to recognize the scientific attitude, background, and work which produced the generalization. The historical approach is one type of this presentation.

The third principle in this process is the satisfaction derived from the study of science. Man has constantly found himself in a chaos and has had an inner urge always to put some order to his universe. Here the physical sciences are so effective that it sometimes blinds students to the need of anything else. This urge to see likenesses, classify, and arrange is everywhere present. Likenesses are seen in two very unlike people and similarities in different scenes. The highest form of manifestation of this urge is found in metaphorical language. Science lends itself so completely to satisfying this aspect of the nature of man that it is frequently over-emphasized and may result in over simplification.

The fourth principle is basic to our present idea of adequate teaching. A curriculum needs revision the moment it has been completed for so much has happened during the building of it. Since experimentation is the foundation of science the continuing advance of a curriculum by examination, revision, and investigation can be carried out in the science field and by science professors. A physical science course should be developed in all general education curricula either small or large, as a contribution towards the continuing advance of the teaching and learning of science.

The preparation for future study, work, or leisure constitutes the fifth principle. A physical science course is needed most for two large groups. First, there are those who will go on the upper division of college but will not take highly specialized technical training. This group will need a working vocabulary, an introduction to scientific thinking, and an interest in scientific matters. The second group, those who will not go on in college but into business, will most often come in contact with science in reading or pursuing hobbies, where a physical science course is certain to benefit them. Vocabulary attainment, primarily from context, sufficient in scope to permit the reading of scientific articles and periodicals, now and in later adult life, enriches the understanding and enlarges the field of the reader. From this reading may come the formation of a new interest for leisure time occupation.

The sixth basic principle is fundamental to classroom procedure. In a science course experiments should be simple and should be the introduction to and not the review of the problem. Being able to obtain an answer quickly to a problem stimulates a young person to further thinking. Delayed answers dampen the interest. Devious and complex set-ups do not whet the scientific appetite for learning. The simpler the apparatus the greater is the concentration on the actual problem solution. Therefore, the satisfaction of quicker results compensates for the loss of skill training in a beginning course.

The laboratory experiment in beginning scientific courses that takes up the entire available time and leaves no time for a discussion of the results is almost valueless except as a drill in skills. Experiments that are determined with the end in view of illustrating a principle instead of a piece of apparatus will leave time for the students to answer immediately the problems that they have determined previously. If this answering process can take place in a group, the dynamic force makes itself known in added relationships and applications of the problem.

That there are certain fundamental concepts which seem common to all physical sciences is the seventh basic principle. These fundamental concepts should receive the main emphasis as they aid in pattern thinking which is possible in science. Heat, atomic structure, electricity or metric units are common to all physical sciences. These and others may form the basic questions in unit presentation, a method of organization in science teaching which has often proved more effective than any other known method, since young people obtain so much satisfaction from definiteness and opportunities to succeed.

The eighth principle is based on the assumption that man's learning through the ages in science is similar to the processes in individual learning. Again, the historical approach may be used to show how scientific concepts have been arrived at. If man's first scientific advances were in the area of measurements, young people may also begin there and advance to a concept of abstract terms used to measure qualities. Interest as a motivating force is basic to learning. That elusive term, interest, has for a long time summed up the general concept of a motivating force. It has many facets but it is generated and sustained as a student is led to creative work.

The final fundamental principle is concerned with the function of education in the junior college level as being general rather than narrowly specialized or vocationalized. This idea has been in the thinking of educators for some time and has resulted in many experimental revisions in the curriculum. Physical science courses are examples of these advances.

How the subject matter is to be presented forms the core of the second part of this introduction. The presentation itself emphasizes five divisions:

1. The major question, not answerable in a few words, is basic to each unit. This question may be used as an approach and also as a means of merging the completed unit.

2. The orientation or approach deals with familiar things in unusual uses. These activities tend to remove the barrier of entanglement in techniques so often discouraging to beginners. The class members who have measured the circumference of a coin, the diameter of the same coin and divided one into the other to discover a familiar value have begun their orientation into a unit on measurements.

3. The dicision of the major problem in two more direct and simpler problem questions. Under each of these questions are suggested activities which will supply an answer to the problem questions in a satisfying period of a few days. The simplicity of experiments in the suggested activities has a two-fold purpose. Since the course is designed for that rather large group with little or no scientific knowledge or training, the bafflement felt by the student in arranging complicated apparatus, which is an obstacle to solution thinking, has been eliminated. A student should be able to fix his attention on an answer rather than on the apparatus. The second purpose is to provide experiments or activities possible for the small or poorly equipped laboratory. The use of a simple ammeter and voltmeter reading of a student's car battery will help the formation of the water-electricity analog. Finally, when all the problem questions are answered it will be possible for the student to answer the major question on the differences between heat and electricity in generation, use, effects, and units of measurement.

4. Desired outcomes, understandings, skills, vocabulary, appreciation and attitudes. Among the desired outcomes images will be of great importance. In this constant striving that must take place in the process of communication between instructor and students, between textbooks and students, between student and student, and between world and students, the image is the bridge over which the ideas may pass. These images may be suggested by simple words but their understanding may result in a perception of a complex word in its connotative as well as its denotative meaning. Longitudinal vibration may only be words until the image of rebounding marbles or billiard balls explain the to and fro motion as well as the force causing additional motion.

The primary image introduced by a new idea may explain many things. This is particularly true to the beginning scientist. As information increases the image becomes more refined and clarified. Scientific observations continue the growth of the image until the student is capable of phenomenological imagery.

All things that have taken place in this complex world of ours have taken place first in the mind of man, and so the images have become realities. Man has seized upon these realities to use them as the basis for further developments and so the visions of man become the realities of life and in turn these realities become the images that light the way to new realities.

The science professor has a two-fold task in assisting young people to think scientifically, particularly with images. First, the beginning image must be as simple as is practicable without discouraging the imaginative efforts. A pertinent question may be the means of this. If water is separated by electricity into its two components during the orientation period, and then the components are caused to unite with a spark the question asked at that point "If electricity can separate and combine these two elements, what is the possible explanation of the nature of the matter of these two elements?" may in itself prove a spark to unite the group in the formation of an image that will vitalize the class. One of the first images that caught the imagination of the scientist was Dalton's simple diagram and so in turn diagrams on the chalk-board may start the thinking of a budding scientist in the class. Even a verbal explanation couched in figurative language may produce a meaningful picture. Simple apparatus, however, is the most useful for here its availability to the sense of touch, smell, hearing, or taste as well as sight makes effective its use to stimulate simple images.

The more difficult work of the teacher is in the direction of the group dynamics to arrive at a concept image. As has been said before, these are not always the same for all students and they must be checked and tested on every point. The Damascus blade is only arrived at by constant refining with heating and cooling. Nor may the process take too long a time; for first or second year students, no matter how well motivated, must be satisfied.

5. This division which is the culminating activity may serve as a rewarding experience. A miniature coal gas production plant made by some students may be on exhibition for several days in the laboratory. Finally, the evaluation must take place. Image representations, quizzes, problems, reports, demonstrations and skilled tests are some of the suggested means of this final step. However, no unit is complete unless scientific curiosity is aroused by questions or experiments that will lead into the next unit.

A FUNCTIONAL AND SPECIFIC LABORATORY PROGRAM FOR A GENERAL EDUCATION COURSE IN THE EARTH SCIENCES *

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It is not very often that one finds an article on a laboratory program for a general education course in the physical science survey field at the college level. Hence, I eagerly read this article by Anton Postl of the Oregon College of Education, Monmouth, Oregon, in the October, 1954 issue of *Science Education.*

The title of the article attracted me, and probably many others teaching the same course I have been searching for a concrete science laboratory program on this level, but I was disappointed because I failed to discover the answer to my problem. The principles set forth I heartily agree with, but I was seeking for work-a-day laboratory exercises as others probably were. Since this was not in evidence, I here offer a definite program which is being used at this college and which we have deemed satisfactory through experience. I believe physical science survey teachers are looking for this, be they in liberal arts colleges, schools of education, or teachers' colleges.

* Due to curricular changes, this course has been discontinued. In its place separate courses in astronomy, geology, and meteorology are offered, but the activities described in the article are still being practiced. This change was made subsequent to the writing of the article.

Our students are entering the teaching field on all levels and it behooves them to become acquainted with the materials, supplies, and equipment used in the physical sciences. To those who intend teaching in the elementary schools our laboratory program becomes vital since these experiences can be used by them to open the doors of interest and further activity for their children.

I also realize that there is a dearth of laboratory manuals in the field of the survey of the physical sciences and I was obliged to write my own in astronomy, geology, and meteorology. The tenets set forth by Anton Postl are embodied in the exercises in my manual.

The following is a list of the exercises. Since all of them cannot be covered in the time allotted we are free to select.

1. Astronomy
   - 1.1 How to Make and Use a Planisphere
   - 1.2 How to Construct and Use a Starclock
   - 1.3 How to Construct and Use a Sundial
   - 1.4 The Globe: Latitude, Longitude, Time, and the Analemma
   - 1.5 Relative Sizes and Distances of the Planets
2. Geology
   - 2.1 A Study of Some Common Minerals
   - 2.2 A Study of Some Common Igneous Rocks
   - 2.3 A Study of Some Common Sedimentary Rocks
   - 2.4 A Study of Some Common Metamorphic Rocks
   - 2.5 Reading Topographic Maps
   - 2.6 How to Make a Topographic Map
   - 2.7 Effects of Running Water
   - 2.8 Effects of Wind
   - 2.9 Effects of Subsurface Water
   - 2.10 Effects of Glaciers
   - 2.11 Effects of Waves and Currents
   - 2.11 Effects of Folding, Faulting, Volcanism
   - 2.12 Effects of Stream Deposition
3. Meteorology
   - 3.1 How to Read and Interpolate Instrument Scales
   - 3.2 Determining Dew Point
   - 3.3 How to Read Weather Maps
   - 3.4 The Determination of Relative Humidity
   - 3.5 Climatology of the United States

It is our intention to make this a functional course for those who will be teaching these sciences and for those who are pursuing it as a general education course. One's performance in the teaching of science will be poor unless one has a working knowledge of the exercises and experiments in the physical sciences. Lecturing and demonstration methods are insufficient and inefficient means of learning science. The exercises listed above, with their concomitant readings, will give students a firm foundation in some aspects of the earth sciences and give them practice in constructing visual aids which are so necessary in teaching the young. Children ask questions about their immediate environment and I believe that these exercises will set the teacher on the road towards answering these questions in the manner children understand.

Just as important as the laboratory work is a knowledge of the phenomena which occur out-of-doors. In our astronomy work the students have classes at night to practice using the planisphere or star map to identify the constellations and stars, to use the star clock, and to use our two telescopes. They learn how to use the sundial and compass and they are conducted to the Fels Planetarium in Philadelphia, a visit which is both instructive and entertaining.

In geology we take our students on trips to a nearby quarry to learn physical geology, to another site to learn historical geology, and to the New Jersey State Museum to observe and study their geological exhibits.

In our outdoor activities in meteorology the students learn about the clouds, the location of highs and lows by noting wind directions, the type of weather associated with these pressure areas, why the relative humidity is usually different from that indoors, and the use of a weather station. All these activities are described in the laboratory manual I felt was essential to directed teaching.

I am convinced that our laboratory program in the earth science survey course is a well-rounded one for the future school teacher and the student in a general education course.

THEN AND NOW IN SCIENCE EDUCATION: A CONSIDERATION OF SPECULATIVE AND OPERATIVE APPROACHES

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KING SOLOMON was noted for wisdom. By the means of Slave Labor, of the compass, the level, the square, and the plumb-rule he built a magnificent temple. A *compass* may have a pencil point and a metal point. If there are two metal points it is known as "dividers." Sometimes it is called a "pair of compasses." One has to be careful with this vocabulary. *Level* means exactly horizontal. A wall should be plumb vertical. A *square* has right angles such as a T-square or a "square of glass." A mariner's compass enabled the architect to face the temple east or any other direction. These are four *operative tools.*

We can also use these same terms in a *speculative way.* When Spenser said: "To which he levels all his purposes" he was thinking "on the level" or it was level consideration. Milton said: "Plumb down he falls"—he meant straight down. Sounding means to find the depth of water by a plumb line. We use the term sea level but later we learn that the sea is not level but curved like the surface of the earth. We say that the temple is built four square or that it is "four square up Main Street." The village square is an open area and usually square. We also use the word square to refer to honesty or justness of conduct. Level consideration has to do with even handed justice. *Operative* (opus, to work) is acting physically with the hands. *Speculative* (spectrum, a specter) is acting theoretically with the mind.

It is not always easy to distinguish between *operative* and *speculative.* King Solomon's temple gave the Hebrews a place to worship. It was there that they developed tranquility. They had a place to develop moral principles and a philosophy. At Crater Lake there is a watch tower (specular) where tourists get a panorama of cinder cones, glaciated peaks, and a crater with a lake. The visitor speculates on what has happened geologically. He goes on a caravan trip and sees glacial scratches, stumps turned to charcoal, and the pumice desert. He can sense these with his hands and eyes (operative). I met a man at Yosemite with a mirror (speculum). By use of this mirror he was looking at the scenery in back of him. Every view was in a frame. He called me over to enjoy his speculativeness. The scenery was magnificent. A ranger-naturalist is employed to deal with *operative science.* He is responsible for an interpretative program.

One time an Arab was enjoying a fig. The scientist, with the aid of a compound microscope, showed the Arab that the fig was covered with millions of germs. The Arab grabbed the microscope and smashed it against a rock. I would not deny the visitor to a national park the view (a wide prospect) or the vision that he wished to get in his mind. I would not deny anyone the enjoyment of figs. Sputniks travel by operative principles. There has also been much speculativeness about sputniks. Operative and speculative activities have been with us for many centuries.

Captain Christopher Jones, Mayflower I, had 102 passengers crowded to the gunwales, babes in arms (and in embryo) plus officers and crew (30 seamen). There were no lighthouses to guide them, no charts of the new world, and no mayors to welcome him. The charter called for settlement south of the Hudson River. He was greeted by autumnal equinox storms. He stood off the Cape Cod cliffs and headed south. When off Chatham he "fell amongst dangerous shoulds and roring breakers." It was his judgment that turned the Mayflower about.

The ship came to anchor in Provincetown Harbor. Skipper Jones was a skilled navigator (able seaman) or Pilgrim history would have ended on Pollock Rip Shoals.

The Pilgrims were "babes in the woods." Their first science teacher was a gentleman named Squanto. He taught them how to dig clams, how to catch fish, how to arrange 4 herring in a hill of corn, how to smoke a pipe. They had never seen corn, pumpkins, beans, succotash, nicotina, or a peace pipe. They climbed trees to escape lions. They expected to plant cotton. They drew up a celebrated document (Mayflower Compact) that had much legal jargon and those who had the privilege of "Mr." ("Master") signed first. Some declined to sign. The women were not allowed to sign. All these doings were extraordinary but *operative*. Squanto's education had been operative. He was the prototype of Mark Hopkin's student who sat on a log. Squanto learned by physical action. His laboratory was the outdoors. He spoke two languages. He was peace-loving. He saved the lives of the Pilgrims. He was an educated man, for his day.

Speculative things developed out of the Pilgrim action. It is doubtful if they even noticed the granite boulder brought to Plymouth shores by the glacier. By means of levers, pulleys, and ox power the rock has been moved three times (operative). It was not until Daniel Webster orated at the bicentenary (1820) that it took on national significance as the symbol of democracy (speculative). Henry Wadsworth Longfellow wrote hearsay tales in the "Courtship of Miles Standish" (1858). The doughty Captain, John Alden and Priscilla, were well received as Pilgrim mythology. Priscilla Mullins was a "Pilgrim Maid" but never a "Puritan Maid" (Massachusetts Bay Colony). What does it matter that post cards had the Pilgrims living in log cabins when they sawed out planks? If one would know the operative Pilgrims he should read Bradford's Plimouth Plantation" (1606–1647). Poetic license also has a place. For a speculative tale of the Pilgrims turn to Webster and Longfellow [1]. The Pilgrims gained political and religious freedom.

The Pilgrims were *operative* when it came to agriculture, fishing, hunting, spinning, cooking in brick oven, butter making, liquor, and tobacco. They were *speculative* when it came to Satan, Hell, sin, witches, baptism, card playing, profaning the sabbath, dancing, killing toads and snakes. We are *operative* when it comes to words in a deed, driving an automobile, putting up school buildings, setting aside a national park and identifying trees. We are *speculative* when it comes to trading in an automobile, estimating the cost of school buildings, speculation in land or stocks, or proving a theorem in geometry.

Humans (most at least) have always been slaves to notions. Surgery is operative. Before anesthesia (1846) the sawing off of a leg, the poking of stones out of the bladder with the hands, and the delivery of a child were pretty crude. In the Civil War as many soldiers died from infection as from bullets. The use of antiseptics came slowly. Today we have successful surgery of the lung, thyroid, gall bladder, larynx, eye, brain, and kidney. From experiments with animals it is possible to install a new kidney. Each step in surgery has been buffeted by disbelievers, and idolators (speculative). *Operative science*, in war or peace, wins by radar, sulfa-drugs, atoms, blood pressure. In *speculative terms* of ethics, humaneness, law, and government we also need men of good will. *All society must assume the responsibility of scientific discovery* [2].

The International Geophysical Year (July 1, 1957–December 31, 1958) witnesses a joint effort of world scientists. They are teaming up for the future by observing whether polar ice caps are advancing or retreating. Solar astronomers are watching the sun 24 hours a day to get an earthwide picture. The ocean is rich in content. Outer space belongs to the nations. Scientists expect to exceed the 20-million-degree temperature of the sun.

Heavy Hydrogen is called "deuterium." The British have a machine called Zeta (zero energy thermonuclear assembly). The British and Americans believe that they can get fusion in the laboratory. Operative scientists are playing with forces that power the stars. They are doing things that seem speculative. Today, more than ever, individuals not specializing in science need to understand science. If legislators understood science they might do better. An iron curtain and patriotic security cannot muzzle scientific security. *An atmosphere of peace and trust is required. These things have been achieved by science.*

We have seen that *operative science* has a past and a present. It also has an unknown future. There is a shortage of operative scientists. The *speculative public* does not understand the needs of science education. They do not understand that higher taxes and increased appropriations do not buy scientists. They do not comprehend that expensive laboratories and apparatus do not make scientists. They read that teen-agers, instead of hot-rodding, are going all-out for homemade rockets. Encouraging youth to enter science is not enough. There must be well-trained teachers and facilities. Some educators say that educational practices do not give enough time to science. Other educators say that there is a danger of giving too much time to science. No wonder that speculative people get bewildered. Speculative thinkers know that the size of the globe has been reduced. They know that some people are still on low standards of living. They realize that operative scientists are aware of the implications of science. The standard that has not been achieved is that *speculative co-workers as well as scientists must know that Science is related to human obligations and responsibilities. Periodic wars do not pay. Philosophy, literature, art, and religion, as well as science must unite for a higher standard of living for all.* This is not crystal gazing, magic, or miraculous. It is already achieved in the Antarctic and by teen-agers. It is simply *extending the frontiers of cooperative knowledge* by combining new discoveries such as was done with the electric light bulb, the automobile, cortisone plastics, and high octane.

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DISCUSSION OF THE RATIONALE AND PREVIOUS FINDINGS OF THE "IS OF IDENTITY" TEST AS A BASIS FOR FURTHER RESEARCH *

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THROUGH the medium of language, an attempt is made to convey the thought of the scientist, the educator, the psychologist, the theologian, as well as the thought of the men in the street. If one is to learn about those things which he cannot experience at first hand, he must do so through the medium of language. Without this invention of the human species future generations could not profit from the experiences of the past, nor present generations communicate through vast distances. Language is not the special province of any one area of knowledge; it is utilized by every area. For this reason, research dealing with language itself must draw from many, many areas. Examples cannot be gleaned from

* Part of a paper entitled "Three Experimental Studies Aimed at Testing Korzybskian Principles" presented at the 32nd Annual N.A.R.S.T. Meeting in Atlantic City, Hotel Dennis, February 20, 1959.

dictionaries nor from texts dealing with rhetoric, logic, or grammar alone; the reason for this being that the importance of language is not in the language but in what human beings do with it.

Many authors, including Malinowski [1], Mead [2], and Whorf [3], to name but a few, have shown that the way in which man interprets his world (reality) is a function of his language. "The language which man uses is determined for him by his culture and because individuals within that culture talk fluently from early childhood each man believes himself to be an authority on the process" [4:230].

Obviously, language is the chief media for communication among humans. This language and the structure of it has been handed down through the ages, incorporating the ideas of men about the structure of their environment, both inside and outside their skins. Some of these ideas were correct; much was incorrect due to the limited knowledge early man had of his world. Through empirical testing much of the erroneous information has been corrected, but the structure of the language has not changed greatly, and it is that structure which does not correspond to empirical reality.

The discipline called general semantics (a discipline based on scientific, non-Aristotleian principles—not to be confused with semantics) is based on the premise that the structure of a language in which men expect to deal with and describe the "real world" around them should be similar to the structure of that "real world." Or, if that similarity of structure is lacking, the men who use the language should be aware of its limitations which can lead them into pitfalls of misunderstanding and misevaluation. General semanticists point to the "IS of Identity" as one of these limitations. If its unthinking use can lead to misevaluation and misunderstanding, then it may be both a precursor and a symptom of maladjustment. The problem may be one of structure, and if this be the case, the "IS of Identity" may be one of the culprits.

Carl Rogers has suggested that "the whole task of psychotherapy is the task of dealing with the failure in communication [5:83]. If this be true, then any and all techniques which have been or can be developed to indicate the cause of such communication failure should afford a basis on which educators can build a communication system less subject to such failure. Great efforts have been made in this direction, and with notable success. The whole area of group dynamics involves communication between people, but if, as Rogers says, "The emotionally maladjusted person, the 'neurotic' is in difficulty first because communication within himself has broken down . . ." the need is first for improved communication individually.

Counselors and psychotherapists as well as psychiatrists attempt to do this, attempt to establish communication with those who "are out of contact with reality." Each of these specialists recognizes the language peculiarities of special mentally disturbed persons, but in none of the literature outside the field of general semantics is there reference to the possibility that confusion of levels of abstraction or the habitual use of the "IS of Identity" may be causative factors, although Katz [6] has evidenced interest in the problem and invites research.

In the October issue of *Science Education* 1956, a study applying "Non-Aristotleian Principles in the Measurement of Adjustment and Maladjustment" was published. This study revealed that there was a significant difference between those habituated to the use of the "IS of Indentity" and those who were not, as evidenced by the differences in mean scores between institutionalized persons and non-institutionalized persons as well as by significant differences at the 0.01 probability level in teacher-ratings of students in public schools. Five hundred and thirty-four students were tested. If these findings were correct, social adjustment could be predicted on the basis of scores earned on the "IS of Identity" test. With the reliability .94 the fundamental question that remains is whether the test is valid. With no comparable paper and pencil test available the validity of necessity had to be determined by (a) comparing by correlation and analysis of variance or analysis of variance with co-variance adjustment, teacher-ratings with "IS of Identity" test scores for those in public schools, (b) comparing by analysis of variance "IS of Identity" test scores of the total public school group with "IS of Identity" test scores of the total institutionalized group.

It is important to keep in mind the limitations of the study, namely:

1. The fact that no instrument was available against which to validate the test might be considered the most serious limitation.

2. The populations studied were restricted to the Michigan area. Whatever generalizations that might be drawn need to be handled with care and with full recognition that they were only indicative and not to be considered final in any sense.

3. This study shared with all other paper and pencil test studies the possibility of misinterpretations of instructions. Every effort was made to administer the test in the same manner during each testing period.

4. The inequality of teacher-ratings, that is—one student may have a "mean rating" reflected by ten or more teachers, another student may have a "mean rating" from but one teacher. The student "known" by more teachers had more ratings and was usually a student at one or the other extreme of the adjustment scale. While these extremes were valuable in discriminating extremes, the in-between students were equally important and faulty rating of this group may have reduced the correlations found between the test and teacher-ratings.

5. This limitation arises because students were told scores would not affect their records in school. Perhaps a recognition by the student that he would neither gain nor lose may have affected his approach to the test and hence his score.

6. Another limitation of the study was in the nature of the test itself. The items were extremely simple, deliberately so. This was in order to eliminate reading ability as a factor. All items were keyed false. Care was taken that a pattern of response could not be detected (except in rare cases), and several trial forms were used from eighth grade level to fifth year college level, which verified the fact that an all-false pattern could not be discerned. None-the-less, in the "rare cases" mentioned (and this has not been definitely established) some detection of the all-false pattern may have occurred.

7. Finally, the group in mental institutions, the most seriously maladjusted, was not tested. This group, in whom communication failure is most complete, was left out of this experimental study because of insufficient time, too few cases (of proper age group), and because of the obvious difficulties of administering the tests or even of getting permission to administer them. The results of this research may indicate full justification for a more comprehensive testing which could then include those in mental hospitals.

Using the statistical technique of Analysis of Variance, the study indicated that one *could* reasonably conclude that variation in test scores earned on the "IS of Identity" test *were not* associated with age, set, grade level, church affiliation and/or attendance. One *could* assume that inability to adjust to society might be a consequence of inability to solve problems. If this be true, perhaps the "IS of Identity" test could be used to determine whether individuals habituated to the use of "IS of Identity" were less efficient in problem solving than those who were not. If individuals who tend to structure their language in a manner similar to the structure of the "real" world solve problems more efficiently, one might conclude that such individuals possess fewer false-to-fact notions. Two relatively simple tests were administered to Freshman students at Arizona State University at Tempe which attempted to test these hypotheses. In the second paper of this series the effect of identification on problem solving will be discussed, while the third of the series will deal with the relationship between false-to-fact notions and identification.

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IDENTIFICATION RESTRICTS PROBLEM SOLVING *

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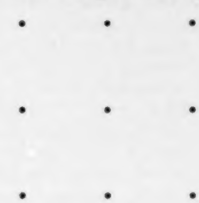
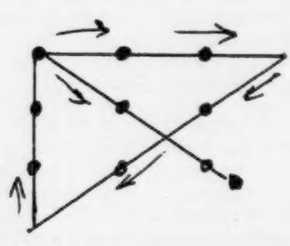
THE previous paper discussed a paper and pencil test developed by the author which purported to measure the degree to which students were habituated to the "Is of Identity." Subsequent studies confirmed the reliability established in this study and tended to support its validity when used as an instrument to determine the social adjustment of an individual. Deviation in an individual's score from the mean of a group proved useful in counseling situations, particularly in those falling below the mean. In working with such individuals in a non-directive counseling situation, aimed at alteration of their perceptual framework, several interesting possibilities arose. Alteration of language habit patterns not only prove helpful in reorienting a student socially but subsequent behaviors of students seemed to indicate that a different attitude toward academic work was a concomitant. It was considered possible that elimination of false-to-fact identification resulted in better methods of problem solving. In other words when a student was able to define a problem situation differently than he had previously defined it perhaps solution became easier. If this were true, elimination of false-to-fact identification enabled an individual to perceive a situation from many different "angles." Obviously a "hunch," based on a limited number of "problem" cases, is useful only if the "hunch" can be framed in testable hypothesis and subjected to experimental testing. Further, if elimination of identification enables students to solve problems better, it should be true that students who are less habituated to identification *to begin with,* should be better problem solvers. Since there are more students available for testing who are not "counseling cases" than who are, it was decided to compare scores earned on the "Is of Identity Test" with scores earned on a problem solving test. If students who scored low on the "IS of Identity" test also scored low on the problem solving test and conversely, perhaps further research would be in order to determine whether problem solving can be best insured by directing our attention toward correction of faulty language habits than by other methods.

The "problem solving" test had to be one which did not rely on previously learned materials and/or methods. It had to be a unique problem for "all" students. After considering a dozen or so tests ranging from a test of fifty items to one, the "nine-dot problem" test was adopted. Students of psychology will recognize the problem.



Direction: With four straight lines, connect all nine dots without retracing and without taking your pencil off the paper.

Solution:



Sixty-four students in two sections of a beginning professional course in education

* Part of a paper entitled "Three Experimental Studies Aimed at Testing Korzybskian, Principles" presented at the 32nd Annual N.A.R.S.T. Meeting in Atlantic City, Hotel Dennis, February 20, 1959.

took both the "IS of Identity" test and the "Nine-Dot-Problem" test. Arranged in seats so that they could not get clues from their neighbors, the students were given as long as needed to solve the problem. Scores were arbitrarily assigned as follows:

Solution time 5 minutes	100
10 minutes	90
15 minutes	80
20 minutes	70
25 minutes	60
30 minutes	50
35 minutes	40
40 minutes	30
45 minutes	20
Over 45 minutes	0

Upon completion of the tests students were asked to leave so that they would not distract other testees. Possible scores on the "IS of Identity" test, previously reported were also 0 to 100.

Since the study discussed in the preceding paper conclusively showed that age, sex, grade level, church affiliation and/or attendance could not reasonably be associated with scores earned on the "Is of Identity" test, it was assumed that these variables would also show non-significance when applied to the "Nine-Dot-Problem" test. The assumption was not tested and, consequently, casts some doubt on the validity of these findings. Such an assumption, however, seems reasonable in light of the fact that "all" data necessary for the solution of the problem was available to "all" students. While admittedly each student had different inheritances and different past experiences, some commonality can be assumed by virtue of their each having been admitted to University. Since this research was undertaken on a "pilot study" basis to determine whether a larger, more rigorous one was justified, the only statistical procedure employed was a shortcut measure of correlation.[1]

The Standard error for the "IS of Identity" test was 9.4 and for the "Nine-Dot-Problem" test 19.0. The correlation coefficient was .85. There *is* a strong positive relationship *IF* the assumptions in the previous paragraph are valid. On the basis of this study *alone* no conclusions can be reached except that a larger study is justified. A replication study is now underway using analysis of variance with covariance adjustment which will be reported in a later issue of *Science Education*. If the outcomes of this subsequent study confirm the findings of this present "pilot study" teachers and counselors interested in developing better problem solving behaviors in students may well consider paying greater attention to the language habit patterns of students.

[1] W. A. Spurr, "Short Cut Measure of Correlation," *American Statistical Association Journal*, 46:1951, pp. 89–94.

IDENTIFICATION AND FALSE-TO-FACT NOTIONS *

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DURING the year 1954–55 the author of this article was charged with the responsibility of initiating a psychological counseling service for the thirty-eight northern counties of lower Michigan.† In several of these counties a comprehensive testing program was undertaken and in a few, time permitted actual counseling of students with problems. The obvious limi-

* Part of a paper entitled "Three Experimental Studies Aimed at Testing Korzybskian Principles" presented at the 32nd Annual N.A.R.S.T. Meeting in Atlantic City, Hotel Dennis, February 20, 1959.

† A joint appointment with the State Department of Public Instruction and Central Michigan College.

tations of time and distance precluded protracted counseling with emotionally disturbed students. Teachers referred only those students who, on the basis of measured intelligence and evidenced interest, might profit from a single counseling session. Students, teachers, administrators and parents all posed the question "Why should children with above average intelligence have difficulty in achieving in the usual school subjects?" There were, of course, many possible answers, but no one answer. To suggest that there were as many answers as there were individual children emphasizes a fundamental premise with respect to individual differences. Each of those who posed the question, as well as the counselor of whom it was asked, recognized that attitudes of parents, adequacy of earlier teaching, proper study habits, availablity of reference material and social and emotional adjustment were factors to be taken into account. Yet, a fundamental fact remained: many students with far more problems in each of the above areas and with apparently less favorable hereditary potential were achieving better than the students referred.

It must be admitted at the outset that the personnel records on these students were far from adequate and that there were undoubtedly important factors operating about which the counselor knew nothing, nonethe-less some hypothesis and operational procedures had to be suggested on the basis of the information available, if some help were to be given the student. Even though it might be true, as it probably was, that different students achieved less well than others for different reasons, it seemed important to ask if there were any common characteristic that might be observed? Recognizing that "one finds what one is looking for" the evidence, never-the-less, seemed to be accumulating that to a greater degree than "normal" these students had acquired more false-to-fact notions about the world in which they lived. These notions were, strangely enough, ones that could be but had not been submitted to observational testing. Might it be possible that students, such as these, once having "learned" an untruth about process reality, continued to react to what they had improperly learned as if it were "more real" than the empirical evidence at hand? If so, were they not identifying what they believed with what is?

Examples of the false-to-fact notions held by the students interviewed were: Barking dogs don't bite; toads cause warts; lightning never strikes in the same place twice; moist air weighs more than dry air; only brilliant children can master mathematics; still water runs deep; parents can "mark" their children, etc.

More than one hundred children were "counseled" during the year, a large percentage of whom seemed to have amassed a wealth of false-to-fact notions about their world. Further, these notions seemed highly resistant to change, empirical facts to the contrary. Now, obviously, what seems to be and what is, need not necessarily correspond and therefore, in order to support or refute the hypothesis, experimental testing was needed. Perhaps it would be possible to develop a "myth" scale which would incorporate items one would not expect students to accept if they were reasonably observant. For example, most observers would agree that barking dogs DO bite more often than non-barking dogs. Adults who smoke are everywhere observable to contest the notion that "smoking stunts growth." During the past three years sixty-four such items have been developed and incorporated in a "myth" scale. Since false-to-fact notions are contradictory to empirical fact and absolute identity is also empirically false-to-fact, one would expect a close relationship between acquisition of false-to-fact notions and habituation to the "IS of Identity." Expectation and realization may be at variance and therefore this assumption too must be tested.

The population which gave rise to the original hypothesis was no longer available to the experimenter, due to change in assignment. The "new" population differed considerably by virtue of greater maturity and education. However, if the original contention were "true," namely, that false-to-fact notions were resistant to change, then any "normal" population should suffice.

Thirty-four students in a freshman orientation class in education comprised the sample. The "IS of Identity" test was administered during the first half of a regular class period and the "Myth" scale during the last half period.

RESULTS

	"IS of Identity" Test	"Myth" Scale
Standard error	7.0	8.0
Range	51–95	22–59
Correlation coefficient:	.96	

LIMITATIONS

The first limitation relates to the validity of the "Myth' 'scale. No validation study was conducted and therefore the validity is purely face validity.

The second limitation is the non-control of the variables of age, sex, religious affiliation, grade level and intelligence which while "proved" to be non-contributory to performance on the "IS-of-Identity" test[1] might be significantly contributory to performance on the "Myth" scale.

The third and perhaps most significant limitation is the possibility that the "Myth" scale is merely an alternate form of the "IS of Identity" test. The very high correlation between the two instruments would lend support to this possibility. It must be pointed out that extreme care was exercised in structuring the items of the "Myth" scale so that no form of the verb *to be* was incorporated, however, the testees may have mentally structured the "IS of Identity" into the items. It is entirely possible that this study simply substantiates the high reliability previously established for the "IS-of-Identity" test (.94).

[1] See selected reference No. 4.

CONCLUSIONS

It is impossible to conclude that the "Myth" scale and the "IS of Identity" test are two separate measures. One can conclude (with great reservations) that false-to-fact notions once acquired tend to endure. This is supported by the fact that eight out of thirty-four students scored less than forty on the "Myth" scale. One can conclude also that either students who are habituated to the "IS of Identity" possess more false-to-fact notions about the world than those who are not *OR* false-to-fact notions contribute to identification. In light of the fact that five out of thirty-four students scored less than sixty-five on the "IS of Identity" test one can conclude that if the findings of the original study were correct, approximately one-seventh of college freshman will need assistance adjusting to college life.

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